PROCEEDINGS

OF THE

American Society of Microscopists.

EIGHTH ANNUAL MEETING,

HELD AT

CLEVELAND, O., AUGUST 18, 19, 20 AND 21, 1885.

COMMITTEE ON PUBLICATION:

D. S. KELLICOTT, GEORGE E. FELL, T. J. BURRILL.

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CONTENTS.

PAGE.

I. Annual Address of the President: The Unconscious Influence of Natural Science Studies. By Hamilton L. Smith 5

II. The Actinic and Visual Focus in Micro-photography with High Powers. By Jacob D. Cox 29

III. Some Diatom Hoops: The Question of their Mode of Growth. By Jacob D. Cox 33

IV. Observations on Some Fresh-water Infusoria—with Descriptions of a Few Species Regarded as New. By D. S. Kellicott 38

V. A New Floscule. By D. S. Kellicott 48

VI. On Immersion Objectives. By Ernst Gundlach 51

VII. Poisonous Dried Beef. By H. J. Detmers 54

VIII. Some Remarks on Fat-infiltration of the Liver. By Louis M. Eastman 60

IX. Pollen-tubes Again. By John Kruttschnitt 62

X. On the Preparation of Chick Embryos for Microscopical Examination. By W. P. Manton 66

XI. First Development of Muscle in the Embryo of the Chick and Man. By M. L. Holbrook 71

XII. Studies of the Development of Cartilage in the Embryo of the Chick and Man. By M. L. Holbrook 76

XIII. Device for Testing Refractive Index of Immersion Fluids. By Hamilton L. Smith 83

XIV. Mounting Media of High Refractive Index. By Hamilton L. Smith 86

XV. An Imperfection of the Eye, and Test Objects for the Microscope. By Lucien Howe 91

XVI. The Uredineæ of Illinois—A List of the Species. By T. J. Burrill. 93

XVII. A Heliostat for Photo-micrography. By S. W. Stratton and T. J. Burrill 103

XVIII. Improved Method of Constructing Slide Cabinets. By Henry E. Summers 108

XIX. A New Form of Life-slide. By Jas. H. Logan 110

XX. Some New and Improved Apparatus. By E. H. Griffith 112

XXI. A Combined Focusing and Safety Stage for Use in Micrometry with High Powers. By C. M. Vorce 115

PAGE.
XXII. Remarks on a Device for Enabling two Observers to View Objects simultaneously. By Jas. H. Logan........... 120
XXIII. Rapid Section Cutting. By Jas. E. Whitney.. 122
XXIV. Remarks on Improved Methods. By R. N. Reynolds......... 124
XXV. Notes on the Epithelium Lining the Mouth of Necturus and Menopoma. By S. H. Gage.. 126
XXVI. Butter and Fats: To Distinguish one Fat from another by Means of the Microscope. By Thomas Taylor.......................... 128
XXVII. Remarks on Stephanodiscus Niagaræ. By C. M. Vorce... .. 139
XXVIII. The Cultivation of Bacteria, and the Cholera Bacillus. By Lester Curtis........... 142
XXIX. Determination of the Absolute Length of Eight Rowland Gratings at 62° Fahr. By Wm. A. Rogers................................. 151
XXX. The Numerical Aperture of an Objective in Relation to its Angle of Aperture in Air, Water and Balsam. By H. J. Detmers................ 199
XXXI. The Working Session:
Schedule of Demonstrations................................ 203
Water-washed Diatoms. By Geo. H. Taylor.................. 207
Cleaning Diatoms from Marine Mud. By Geo. H. Taylor...... 208
List of Mobile Bay Diatoms. By J. D. Cox.................. 210
XXXII. Reports:
Of Committee on Standard Micrometer........................ 212
Of Treasurer and Custodian................................ 213
On the Slides Owned by the Society...... 214
XXXIII. The Necrology:
Thad S. Up de Graff.................................. ... 216
Jas. N. Scatcherd.................. 222
XXXIV. Minutes...................................... 224
XXXV. List of Members.. 251

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF MICROSCOPISTS.

EIGHTH ANNUAL MEETING.

ANNUAL ADDRESS OF THE PRESIDENT:

THE UNCONSCIOUS INFLUENCE OF SCIENCE STUDIES.

HAMILTON L. SMITH, LL.D., Hon. F. R. M. S., Geneva, N. Y.

In selecting a theme, proper for presentation upon an occasion like this, I have experienced no small difficulty. The Presidents who have preceded me have well-nigh exhausted all that could be said upon the history and applications of the microscope, and I labor under an especial disadvantage in appearing next after the able statesman and soldier whose counsel and wisdom contributed so materially to the success of the meeting at Rochester last year. Indeed, I must here be allowed to say, that had I been present at the close of that meeting I should, peremptorily, have declined to accept the high honor conferred upon me, and would have urged the claims of others of our members who have contributed far more than myself to make our Society thus far a success.

In the great field of physical science, especially that branch of it which demands the most of my time during the year, astronomy, the use of the microscope comes to me as a recreation, fascinating and every way pleasant, but yet not, as to the biologist, the all important instrument, without which not the first step in advance can be made. In this great and all important, I might almost say, the most of all important, science, we have many earnest and genuine

workers, the results of whose labors cannot yet be estimated; and it would have been proper recognition of the value of the microscope in this field, if you had selected some one more familiar than myself with such studies, to have presented to you a *resumé* of what has been accomplished during the past year, and in this to have found an earnest of what we may hope for during the coming one.

And all the more I regret it now, for as I have been writing this address, far from home, there comes to me the sad intelligence of the death of one of our most honored associates, one who was already well known as a biologist, and one who, by his untiring efforts and zeal in microscopical science, made our meeting at Elmira three years ago such a brilliant success. He has gone from us in the prime of manhood, a victim of a most dreaded disease, the advent of which, and the certainty of a painful end, must have been known to him as a microscopist and skillful physician, long before the fatal termination. None who have ever known him will forget Thad S. Up de Graff. By you and by me will his memory be cherished, as the memory of one of Nature's noblemen, whereof he

> "Was a noble type,
> Appearing ere the times were ripe,
> That friend of mine who lives in God."

And now, as I am not willing to embarrass the movements of the Society by refusing to perform any duty that may be imposed upon me, and within my ability, with much diffidence and relying on your kind forbearance, I stand here this evening as your President, to deliver the Annual Address.

I have said that I have experienced considerable difficulty in the selection of a topic, which, while it might, at least so far as I could make it so, interest a popular audience, yet should not be foreign to the purpose for which our Association was formed. Manifestly, anything about the history of the microscope, the principles involved in its construction, or any sketches of those noble men who have devoted their lives to perfecting our instrument, are themes now closed, and something of a more general character seems to be demanded.

I have thought that, speaking at the annual meeting of a society organized to give a more efficient direction to forces which are con-

tributing so largely to the welfare and growth of a nation, forces which have been, though the outside world was unconscious of it, effecting great changes in all departments of human investigation, and modifying so largely old opinions and habits, I might, in calling attention to the "silent conquests made by sowing the seeds of knowledge," not only contribute my small portion to further the aims of our Association, but might possibly, at the same time, give a new direction to the thoughts of some who have had little leisure or opportunity, hitherto, to study the relation between science and that social development upon which the happiness and well-being of a community is dependent. If I had but the skill to do this, corresponding at all with my ardent wishes, I am quite certain that, in meetings like the present, you would recognize great opportunities for doing good; we have laid aside for a little time our daily cares and toils, and we meet to consider, and to share with all the force of fresh impressions in the criticism and discussions of, the new advancements made in microscopical science during the past year; and, "where each receives some good from another, everybody gains, and mutual respect and kindness is increased."

While, in a general way, then, I take for my theme, the unconscious influence of natural science studies in the development of society, I must subordinate it, as far as practicable, to that particular branch of science which just now claims our attention, for, otherwise, the subject would be too vast, as it confessedly is too important, to be reviewed in a brief hour. I shall be able to say very little as to the unconscious influence of natural science studies in the development of mind, though that, indeed, is by no means the least important part of our subject; but, just now, as more practical and readily appreciated, it will be better to remind ourselves of the improvements in all that concerns our material comfort in the few decades past, improvements that have originated in the study of natural science.

And here, at the outset, I would not be understood as urging the claims of natural science, to the neglect of those other means of intellectual culture which characterize our present system of education; though, even here, just grounds for criticism might be found, especially in reference to the question, as to what a State may or

may not teach in "matters belonging to the domain of conscience." Happily, I am not called upon to discuss this, in inviting your attention to the *unconscious* influence exercised by studies of nature, rather than to any conscious benefits immediately derived, though often the latter may be apparent enough.

When we survey the present condition of society, and attempt to analyse the problems of social relations and intercourse, which have become the topics of so many discussions and have called for so many expressions of difference of opinion, we are apt to lose sight of the more hidden and quiet forces, which, though unrecognized, are nevertheless controlling with irresistible power the movements of the age, and, in spite of the prejudice, the ignorance, the sordid motives, of temporary leaders, sometimes in the highest stations, are bringing good out of evil; and, as the round world itself, in obedience to laws unrecognised by the busy crowd, moves surely and truly on its axis and in its orbit, regardless of the cyclones and storms which, for the moment for us, appear to have the whole mastery of our being, so under influence of these, which are acting as the controlling and directing forces of political and social life, we are safely guided, and know that our hopes of ultimate success have a foundation, true as was the word pronounced when the Creator looked upon the world, with all its sky, its water and its land teeming with life, and behold "it was very good"; yes, and nothing but good can come from the study of this perfected nature, when properly conducted.

There was a time when it was not so conducted, but in a far different manner and this by very intellectual men; a time "when experimental science had no existence, and, indeed, was not believed to have sufficient power to compass nature." To-day, the speculative schemes of the ancient philosophers have vanished before the study of facts, and the world of reality is emerging from the "strange land of cosmological, geognostical, and imaginative dreams," a new creation has succeeded their destruction, and "melodious birth-songs are coming from the fires of the burning phœnix." And yet we have not parted entirely with the ideal world; happily, we enjoy it, in our studies of nature, untrammeled and untroubled by metaphysical conceptions. We care not to bother ourselves to

show by intellectual processes, which probably never can be done, that "cause and effect is but the order of nature"; we feel and acknowledge, as every true student of nature must, the underlying regulative power; the facts may be discontinuous, like those of geology, for example, and sharply marked, draw the line wherever we will, but, as the geologist ideally constructs a progressive world, and as he knows that, on the whole, it is ever from a worse to the better, which is all that evolution can do, so we, microscopists, of all science students, confessing that our senses are far from revealing to us all the realities of nature, do not trouble ourselves with relation of cause and effect in social problems, but leave the leaven we may find, small as it is, in the bushel of meal, quite sure that, in time, the whole will be leavened.

Every branch of human knowledge, every department of human industry, now is feeling the influence of science studies, and slowly, but none the less strongly because unconscious of it, society is being moulded in conformity to its teachings, and developing, with constantly increasing noble and excellent results. "The old world has passed away, the age of the Hero, of the strong leader, is gone. The People have arrived and sit in judgment on who would rule or lead them,—Science has arrived and everything is upon trial." Theology, law, medicine, agriculture, commerce, what may we not include in the list, have, one and all, within the memory of some of us here, undergone wonderful change. The enlargement of corporeal vision, the greater comforts of material existence, the practical annihilation of time and space, the multiplication, almost beyond conception, of the means of spreading knowledge, these and hundreds more like these, so familiar now, are but the outcome of a search for truth, attainable only by man in a reverent study of nature; and the reason is obvious, for while in politics, and in business too often, men attempt to obscure a difficult question, those who "devote their lives to scientific investigations, cultivate a love of truth, for its own sake, and, if anything be obscure, endeavor instinctively to clear it up."

Do not for a moment mistake me; when I claim so much for the study of nature, I am far from saying that this is all which is contributing to the well-being of society; the slightest consideration

will show that there are two independent sources of knowledge, the internal and the external, or, as Whewell calls it, "the string and the pearls strung upon it," and in completed form not to be separated, and the domain of either is broad enough to satisfy the highest ambition. There are those who do not realize this; men often of high culture, and really honest intentions, who believe that the scientific man is one delighting to "spy, smirk, scoff, snap, snort, snivel, snarl and sneer," and who sincerely think that where fact and science come, there imagination must depart and "religion retire, like some ancient indigenous races before the well equipped invaders"; and that, while a few inaccessible mountain-peaks may remain in their possession, yet the rich and open country of every-day life, over which they once roamed in undisputed ownership, will be lost to them forever. And there are some who have no pleasure in being alone with nature. Forever wrapped up in self, unable to separate the great world of truth and beauty from conscious will, it is the same listless cry, What use to me; frittering life away like one who

> "Fingers idly some old Gordian knot,
> Unskilled to sunder, and too weak to cleave,
> And with much toil attains to half believe."

It is a real relief and comfort to turn from this distrust and doubtful faith, and find others who know that something can be done really true and human, and whose labors have already availed to lessen the sum of human suffering, and to bring in the happy sunlight to darkened homes and make nature's sweet music heard by "ears dull with pain." Yes, there is something vastly stronger and nobler than self which is working the tale of human civilization. It was formulated when Fenelon said: "I love my family better than myself, my country better than my family, and the human race better than my country." It is not an outcome from the agnostic's infinite, unknowable sub-stratum, of which we neither know or can conceive anything, nor of the positivist's sum total of humanity, with "the clothes of religion"; no, the mysteries of our being, as Lord Raleigh has said, "if penetrable at all by human intellect, require other weapons than those of calculation and experiment."

In constructing, then, the fabric of human society and placing it on a sure foundation, in providing for the exigencies of the future,

where may we seek for a balance-wheel, a controlling power; and how may we hope to solve the mysteries of social causation? The wisdom drawn from the study of history has failed to give the requisite knowledge in politics, and classical culture has proved inefficient; the experience obtained from the halls of Justice—the lessons of the forum, of the exchange, and of the workshop, do not much help us; and all sober, thinking men concede that neither speculative theology or positive philosophy is adequate to meet the wants of society, or to furnish a remedy for the evils arising from inconsiderate, hasty, or unwise legislation; evils which are, however, constantly staring us in the face, and which must be met.

In discussing a remedy for such deplorable results as depreciation in the value of labor, not always apparent, but nevertheless real, the growth of pauperism, and the "growing despotism of office," ills that have been prolonged or strengthened by the very means proposed, and often honestly advocated, to ameliorate or do away with them, every one acknowledges the failure of sumptuary laws and sanitary regulations, whose authors and advocates, acting in good faith, have found, when too late, that they have put in motion forces which, if they had not been controlled by a more powerful but unsuspected agency, would have effected far more of evil than of good. Under the influence of a controlling power, which is, unseen and unsuspected, permeating and remoulding society, we are already coming to recognize the futility of mere legislative attempts to regulate the hours and amount of labor, and, that universal taxation, for the support of so-called public charities (really support of pauperism), nay, I may even include, in part at least, for the education of the community, in view of the demands now made for a higher education to be supported by taxation, is wrong. I say, that we are beginning to recognize that these, however commendable in theory, as also the absorption by government of not simply the postal system, but, as with mistaken zeal many are now desiring, ultimately that of telegraphy and of railroads, as already of canals and of banking, and so forming a political engine, "controlling, without mercy, the rights and liberties of individuals,"—I say, we are beginning to recognize that these must end as miserable failures; and that the evils that are now more or less upon us, and have been increas-

ing, like all noxious things, not only without cultivation, but despite honest endeavors to eradicate them, must be met and controlled by some more efficient power.

Now, we may call this power religion, education, "culture and sweetness," or even science; under whatever name, its office is, to exalt the search for truth for the love of truth; to oppose subtilty and artifice; to promote a love of the beautiful, and so of literature and art; and above all, that belief and trust, which is the very essence of religion. This is the power which will make a community of nations and beget wise reciprocal intercourse, as already foreshadowed in an international congress and the advances towards the adoption of universal time and prime meridian, and unification of weights and measures. It has been asked: "What better remedy for social evils can be desired than the collective wisdom of the people, embodied in the choice by the people of their leaders?" Granting that this choice has been wisely made, too often, as we all know, not the case, what has been the result? Let Communism and Nihilism reply.

I dare say that we have, many of us, been at some time in the presence of a mighty engine, and have noticed, almost with awe, upon the motions of how small and apparently insignificant a part of the ponderous machinery, the success and perfect working of the whole has depended; or, even if we have not seen this, we have instinctively realized its presence. Happily for society, there is such a regulator, though the mass of the busy world do not recognize it, silently and ceaselessly working to right the wrong, and to keep all right. The little needle, that quivers day and night, in sunshine and in storm, ever faithfully guiding the richly freighted ship over the trackless ocean, is not more true. A careless, pleasure-seeking world may look upon it as only a bit of useless steel for boys to play with, and think as lightly of it as of the rusty nail that the boy is raising with it; and yet, the study of the mysterious forces which cause the nail to cling, has not only opened up in the past, but will yet more and more in the future, possibilities of advance that set at naught the machinations of demagogues, and the ambitions of desperate men, guiding the ship of state in the right path, though these, as the storms and cyclones for many a noble vessel on the

ocean, may sometimes swerve it hither and yon; and so it has come about that civilization is doubtless advancing, with no uncertain tread.

Looking merely at results, one is astonished at the substantial progress; and, best of all, it is a progress which, unlike that of past ages, cannot revert. Here history cannot repeat itself, the evolution is ever from lower to higher, in the order confirmed when the divine Architect looked upon his work and pronounced it, in his sight, very good. In the history of the past, civilized nations have indeed relapsed into a more barbarous condition, or at least not advanced; but a civilization based on scientific facts, and guided and controlled by scientific truths, has no such possibility.

It is entirely beyond my ability to show to you as clearly as I could wish, how a regulating power, the unconscious influence of scientific studies, is directing and reconstructing political machinery, and is, so far, the remedy for social evils; for, while we must allow that such remedy actually exists, you will agree with me that it is not to be found in greater purity in official life,—such an assertion you would meet with an incredulous smile; nor yet is it in wise, even if it be honest, legislation,—such an idea does not mislead anyone; certainly not in the true adjustment between labor and capital, at last happily accomplished,—strikes and the long categories of strife, bloodshed and misery, form the background of this picture. It is not, then, by these, or by any combination of these, that we have a remedy for the antagonisms which exist, and must exist, and which, paradoxical as it seems, when controlled, are beneficial. Nay, our trustworthy hopes for a glorious future are based not on speculative, but on scientific grounds.

If there is any being to be pitied, it is the pessimist, and, closely allied, the agnostic; the one sees nothing but evil, and that continually; the other sees nothing but a grave, in which he buries everything, "and vents his disappointment and resentment on the cold mountains and distant stars, which have no sympathy for him." The true student of nature, on the other hand, as I trust we all claim to be, sees before him a world of promise, of beauty and of love; his hopes for the future are based, not on metaphysical conceptions, nor solely on faith, but on a substantial, real existence,

the evidence of which is drawn from, and founded in, scientific investigations of nature, applied directly,—not far off in the dream-land of philosophy, but at our very doors, in our humblest homes, every day, every moment, assuaging the ills of humanity, nay, making humanity possible and lifting us one and all to the clear light of truth,—giving strength to the weary, hope to the down-trodden and health of body and mind to all.

The electric cables and telegraph wires which are to-day uniting as one, far distant communities, are results neither of speculative philosophy, nor of legislative enactments; they are but a part of the many blessings that science has given to help redeem the world, and which are doing it. The great truths which have made such gifts and thousands of other like gifts possible, all working to the same end, have not been brought to light by studies fostered by mistaken ideas of redressing human wrongs, by relieving deserved human suffering and so setting at naught the decree of the Creator by softening or blotting out the penalty he has attached to sin; nor from studies for love of gain, but for love of truth; and this searching for truth is, I take for granted, the aim of every worker belonging to our Association.

If we accept the Darwinian principle, as I suppose the most of us do, and admit that the development is the natural outcome of the surroundings, we shall find, if we look at it deeply, not superficially, it is the expression not only of what is, but what is to be; a law of morals; and the physical and social factors of man's constitution will be found so closely interwoven that we cannot separate them. True, the fittest, in the natural Darwinian sense, in our yet developing condition, and the fittest in the moral sense, are not always the same now, but we have abundant reason for the hope that this highest condition is one towards which mankind is steadily approaching. The advances already made are great and full of interest; and the pursuit of those studies conducing to physical, mental and moral development alike, is of highest promise. To the truly scientific worker, with this development in view, "no subject is too vast for his research, no object too minute to be unworthy his patient study." Thanks, then, to the resistless, though unconscious, influences of science studies, moving the world to-day, not only is

the pulpit sounding a more healthy tone, but the movement has reached the forum and the workshop.

To-day, to be saintly is not to fly from human contact to some hermit's cell in the wilderness, nor is it to bury one's self in nunnery or monastery. There was a period in the history of the world when this was saintly. In our own time we have known other saints, who, driven by their environment, have entered boldly into the dens of vice, and gone down into the dungeons of despair, bearing not "theoretical fantasies which in the dying leave fallen man yet lower," but with the ever-living truths and possibilities of a regenerated nature working out the only lasting reformation; we have known such, doing their work faithfully, responding, like the tuned string to its chord, in entire harmony with natural law, for, by this law, as Herbert Spencer has put it, "whatever amount of power an organism expends in any shape, is the correlate and equivalent of a power that was taken into it from without;" and so, while to them it was all, and truly, but from a love of Him who first loved them, it was, in a yet more satisfactory way, the confirmation of his declaration, "Without Me ye can do nothing." The great body of faithful students who have interpreted and handed down to the successive generations the eternal truths written in the works of creation and conformed their lives thereto, these are the men who have borne the heat and burden of the day, and they are the last to murmur when those who have been all the time standing idle in the market-place come in and labor but for one hour, and receive the same penny.

It is far from my intention in anything I may now say to urge greater prominence to the study of science or of nature in our schools, or the presentation of science teachings more decidedly in the pulpit; all this is coming in due time and cannot be stayed; over zeal here, as everywhere, will but o'erleap the boundary and work mischief; the improvement is coming and the true reformation, not so much by the conscious as the unconscious influence of truth. The harvest truly is great and the laborers few, but in the future, as in the past, minorities will continue to rule the world, and microscopists, of all students of nature, can most readily comprehend the influence of minute forces. While no one will be so rash

as to declare that the controlling influences which are so powerful to-day have been sought for and put to use as remedial agents, yet one, not on the other hand, can deny that they have originated from a study of nature for the love of truth, and, conjoined with purely intellectual concepts, have become the principles of social life—the ideas of the people and mainsprings of civilization.

A devout student of nature, like Oersted, for example, when he discovered the influence of electric currents upon the magnetic needle, and felt that joy which only a reverent student of nature can feel who presents to the world a real fact, little foreseeing its possibilities,—I say, such a student, has been of far more use to the world than the whole category of noisy demagogues, who have strutted their brief existence on the stage of history, the envy and the admiration of their fellows, but whose careless or mischievous work he has undermined and is to-day undermining; for the whole system of telegraphy, the telephone, and of electric lighting and plating, and—where shall it end?—of widening and regenerating benefits, can be traced back to the discovery made by this simple-minded and devout (for he was a Christian man) student at Copenhagen. I need take but this single instance; it will serve to illustrate what I mean by unconscious influence. A few years ago, when Ohms, and Webers, and Amperes, were unknown, when gas-lights gleamed red and smoky in dark lanes, and cunning men, outstripping the slow mail, put their hands into the pockets of country farmers and merchants (it was a laudable business enterprise—possessing knowledge that was not accessible to these), when criminals were safe, easily eluding tardy justice, when poor but honest homes were denied all the refining influences of art or education, and the silver and the gold came only as heirlooms to the favored class,—in those "good old days" that we are sometimes fond of speaking of, and which have, indeed, a sort of glamour about them in the distance,—in those days when men were old and worn out long before the threescore-and-ten, and grandmothers wrinkled, worn out and toothless at a yet earlier age,—in those "good old days" when the divine right of the king was the master-key of the forum, and when calomel and the scalpel reigned supreme in medical halls, and when theology, alas that it was so, was vainly attempting a tilt

with science, when geologists were akin to infidels, and farmers planted and reaped with the waxing and waning of the moon, were people then really more happy? was society then really better? was there greater individual liberty, or better and truer civilization?

We sometimes, nowadays, talk about the "shocking increase of crime," and of the thousands of laborers thrown out of employment, of the hundred thousand communists who, to-day, in these United State, have a "boundless animosity against all existing social institutions," as indicating that we have indeed fallen upon evil times, and that everything is "going to the bad." On the surface it is a frightful picture, but could we as clearly unfold, as science is now doing through telegraph and press, the sum total of good and evil in those "good old days" as compared with that of the present, the balance would be found far on the side of the present, and indeed it needs no balance-sheet, the general conquest of good over evil is felt and confessed by every one, without necessity of argument.

In looking back, hardly beyond the memory of some of us, we see, indeed, a pretty picture, and this sitting beside a huge fire-place and the blazing Yule-log, is yet pretty,—on the wall. The return somewhat to the cheerful hearth which is coming about, is not altogether an æsthetic drift—nay rather, microscopical science is enforcing it from studies of the impurities that beset us in our homes, and is restoring at the same time the best means of ventilation and of social reunion. It is science that is compelling this, not fashion. Happily, in this case, fashion, and more and more may it be true, is following closely in the steps of science.

To look at it from another point of view, we would scarcely give up our railroads, our telephones, our presses, and our steam furnaces, much less our table conveniences and our luxuries, now necessities, all gifts of science studies, to return to the "good old times." Man is, after all, a "beef-eating animal"; politicians, and sometimes scientists, as doubtless we may show by and by, are reached through the stomach, and when we survey the long rows of ranges, the multitudinous kitchen paraphernalia and house conveniences, we involuntarily exclaim, "How did our grandmothers live?" Live! they did not live; they became prematurely old, their lives were spent in toil and weaving "linsey-woolsey,"—and yet,

they looked back upon their own grandmothers in much the same way, and wondered how they *did* live. This much we may say, they were true to their times, their surroundings, which is the secret of happiness and progress. The same silent forces which are influencing us were moving then, dimly and slowly, for them; the work to be done was then, as now, an advancing work, and nobly, though not always understandingly, was it done. Already, in the generation past, the silent influences of the studies of men like Newton, Watt, Oersted and Davy in general physics, and Linnæus and Swammerdam and Leuwenhoek in natural history, were beginning to be felt; and the quiet, controlling forces, set at work by such men, became, in time, the ideas of the people, correcting the mistakes and bad counsels of leaders, just as they are doing to-day. They were then but as the little streamlets, traversing far off, down the mossy hills, flashing God's sunlight in sparkling drops, falling from frond to frond of ferns, or lying in some exquisite chalice of nature's mould; to-day, those streamlets have united, and, as lively brooks, they water pleasant fields, or as larger rivers, bear down the products of the soil to distant havens, and make one community of widely-separated peoples. To-day, we stand upon the borders of a mighty ocean; the ceaseless ebb and flow, the rhythm of the tides, goes on, as from creation, but the white sails now flecking the far-off horizon are as doves' wings; and to-morrow, that ship of which we have dreamed and which we have watched for, prayed for so long, will surely come in, and will bring to us more than we have dreamed of: gold of Arabia, spices of India, best of all, good tidings from our brothers in other lands, "Peace on earth, good will to men"—that Christmas song, better than the Yule-log of the "good old days," now realized.

Let us believe that we are here to make the world better; not content to remain inactive because there are depths that lie beyond the region of our will and choice. Every gathering like the present one is leaving its influence for the better. True, we do not come here to study out a remedy for social evils, however these may be affected by our studies and our mutual intercourse; this we leave to the keeping of the beneficent Father of us all. We come here to work, searching for truth in the love of truth, for the love of the

beautiful; and if we are sincere in this we need have no fear that the influence of our lives and works will be lost. We sometimes hear about "conflicts between religion and science"; such antagonism is more apparent than real. Under the influence of the very studies which form the subject of our own investigations as microscopists, theology is drifting in the right direction and has already learned, as Carlyle says, "that the public highways are not to be occupied by people demonstrating that motion is impossible," and that religion has nothing to fear, but everything to gain, from an alliance with science. Lowell has well said:

"Science was Faith once; Faith were Science now,
Would she but lay her bows and arrows by,
And arm her with the weapons of the time.
Nothing that keeps thought out is safe from thought;
For there's no virgin-fort but self-respect,
And Truth defensive hath lost hold on God."

It is but a few years to look back, and we find good men no doubt, and honest, fearful and distrustful when geology began to assert her claims as a science. Forgetting that the older science of astronomy had already experienced such a reception, and already confessing that "the heavens declare the glory of God," they were afraid of "the round world that He had made so sure." While, happily now, geology and religion go hand in hand, yet, still timid and over cautious—nay, at first aghast—pious men see heresy in evolution, and atheism in the "survival of the fittest." The leaven is working, however; they have read, but never before knew its depth of meaning: "He hath given them a law which shall not be broken." And I cannot refrain here from bearing testimony to the position of many of the ablest dignitaries of the grand old Church of the English Reformers, in regard to this question; and I need but refer to the distinguished President of the Royal Microscopical Society, who made us such a pleasant visit at Rochester last year, bearing greetings from our brethren of the Empire, and whose hard common-sense, ready wit, and kind actions, demonstrated how little was the antagonism between religion and science.

Not theology alone, medicine, from a different standpoint, and even less defensible, was found but a few years ago opposing science. The drift has overtaken here, and is in the right direction now. I can

remember, and others here present can remember, when the physician who had recourse to the microscope to aid diagnosis was looked upon as a crank, and treated as an empiric not altogether harmless. Soon this came to be done on the sly; then, one by one, the medical schools thought there "might be something in it," and lastly began to teach and require it, and to-day no physician can afford to dispense with the microscope; and though there be, yet, a few of our older practitioners who give a wise shrug when some of the younger brethren profess through its use to gain a deeper insight into the nature of disease—its cause and remedy,—even these are unconsciously drifting and practising in accordance with the new teachings, to the great benefit of suffering humanity.

I have been led away in the opening of this vast subject before me, the unconscious influence of natural science studies, from considering it in its more particular aspect, as affected by microscopical studies, and which appeals more directly to us; and here let me allude to the great science of biology, which may be said to owe its existence to the microscope, and the study of which as now conducted in our laboratories is of the last importance to the world. Here we find ourselves on the borderland of being, and, in dealing with the almost inconceivably minute organisms, "the beginnings of life," we demand the highest scientific skill in the construction of our instruments and the utmost degree of patience and intelligence in their use. In regard to the former, I need not attempt to say anything; you will have, in our working sessions and at our annual *soirée*, abundant opportunity to judge for yourselves; in regard to the latter, the value of our investigations, I trust that our present meeting will not fall behind that of previous years—nay, will show decided advance. So far as the instruments of research are concerned, the biologist is already in possession of almost all his wildest dreams could ask, and already the work accomplished in the study of microbes, the septic organisms, the monads and the bacteria, which swarm in countless millions around and in us, has effected almost a revolution in medical science; and the silent influence of biological studies, powerful as it has been, will yet continue to be felt more and more decidedly, with "infinite possibilities not of man only, but of man and beasts,"—yes, every living thing.

Tempting as it is to try and unfold somewhat the line of progress in biological sciences during the past few years, I find myself quite inadequate to the task, nor, indeed, for my present purposes, is it necessary; for, interesting as it might be to the members of our Association, it would require some one far more familiar with the subject than myself, to make it so for a popular audience. This much I am sure of (and here is where the influence of these studies is moving the masses, and contributing to work out a more perfect civilization), anything that can claim, with assured certainty, to arrest the fearful progress of contagious diseases, of plagues upon our cattle, and blights upon our crops,—anything that can give to suffering humanity a new hold upon life, with better food, with better air, a sounder mind and better developed body, will always find in a popular audience ready and sympathetic hearers.

Now, all this is what biological studies claim to have already accomplished. True, these studies are yet but in their infancy, but there is a promise of unfolding of so much, that it would fail the pen of a readier writer than myself to depict it, and yet be quite within the bounds of truth. Vast problems lie before us yet unsolved, but which will one day be solved. The study of the swarming myriads of bacteria and micrococci, the harmless and the deadly, their relations, the possibilities of change, the effects of culture and successive generations, as affecting the septic and pathogenetic microbes, the true meaning and value of inoculation, all these investigations present immense difficulties, which it would be almost impossible to exaggerate. If we take but a single example, the bacteria of Davaine's septicæmia,—these are so minute that 250,000,000,000 would only occupy a space about the size of an ordinary drop; now, the 100,000,000th part of such a drop has been proved to be fatally infective. Minute as these microbes are, their morphology is approximately within our reach, and the questions, as to how far they are mutable and, if so, under what conditions, and whether functional changes are induced as readily as, or more readily than, morphological, are of the largest moment.

Meanwhile, as to practical results, and that is what most concerns us here, as the indirect or unconscious effects of biological studies, themselves largely due to or encouraged by associations

like that which gathers us here at present, every one will bear testimony to the greatly improved methods of medical practice, of ventilation and sewerage,—indeed, one of the most important functions of microbes is the disintegration of sewage compounds, and their nitrifying action, a process by which nitrogenous substances are made soluble in the soil, and so, available for vegetable growth. When we consider that the germs of these organisms are everywhere present, "in the air, in water, on the surface of every kind of matter, in the interior of bodies living and non-living, within the blood and the substances of the tissues, in all animals and in all plants, at all temperatures, nearly in all parts of the world," and that their presence or absence will, no doubt, yet prove to be one of the most marked characteristics of climate, so that the effect of particular climates or localities on particular diseases shall be scientifically demonstrated,—I say, when we consider these things, why should not scientific men have "microbes on the brain," as has been said in jest? And why, to change somewhat the poet's line, may we not say: "Microbe, the proper study of mankind"? No doubt, the alleged finding of the potent principle of normal and abnormal phenomena in these infinitesimal specks of life may sometimes justify a sneer; but, on the whole, as a witty writer has said, "these discoveries will be scrutinized and tested by the sceptical or critical, and it will be a lucky microbe that comes out of the ordeal with satisfactory credentials; it may well plume itself on its assured position in the new doctrine of infinitesimals, and flaunt its ten-millionth of a millimetre of tail contemptuously in the face of the unbeliever."

In the important matter of sewage, to which I have alluded, the beneficial results to the community, arising from scientific microscopical examinations, cannot be overestimated. Thanks to these studies, undertaken many times, not with this direct object in view but assured that any new scientific fact has incalculable value, not only the influence of the micrococcus in converting noxious matter into innocuous chemical compounds is well understood, but the conditions most favorable for effecting this with rapidity and certainty; conditions which, if not attended to, might render the sewage of a whole town incapable of purification. Not only the effective disposition of sewage with certainty, but the elaboration of

it into material food for plants, and ultimately again for man, is something of such vital importance to the welfare of the community, something which, when accomplished, is such a direct element of civilization, that I feel that I am quite warranted in alluding to it here, as one of the unconscious benefits conferred upon society by science studies; studies of nature that go far, very far indeed, to counteract the evils that arise from false systems of education or misdirected legislation.

It is the great and crowning glory of biological studies, that the student is investigating a world of life; matter, as it comes under his cognizance, is not dead, but fresh and living, and as it is through millions of infinitesimal living agencies that healthy work is being performed, it may yet appear that these minute organisms are the promoters of what we call "normal action," keeping the body sound despite violations of nature's laws, acting with never-ceasing vigilance in every cavity and pore, and at each resting-spell recovering the lost ground, disposing of the body sewage; and thus man, and society as well, through their agency, is coming out of the struggle of "survival of the fittest," yet better, and advancing to higher perfection and development. No field of microscopical research requires better optical appliances, none more care and patience, and certainly none is more worthy the attention of microscopists.

There is another and very important application of the microscope in scientific investigation to which I may allude, though the results here are not as immediately apparent as in biological investigations, and yet who shall venture to name a limit or bound to the beneficial effect which must forever go on widening and strengthening with each newly-discovered fact? I allude to the application of the microscope to geology—not simply to a part, as in mineralogy, but in a more comprehensive sense. It is a branch of science which has already many enthusiastic and capable workers, and training in a petrological laboratory will soon become as necessary and important a part of a geologist's education as in a biological one already is to the modern physician.

Of the benefits conferred upon society by geological studies, I need scarcely attempt to name them. Marvelous, indeed, has been the growth from wilderness to great cities. Railroads, the telegraph

and the tide of civilization, have followed the sound of the hammer and chisel of the geologist, and to-day our great country is one busy field of workers; the coal, the iron, the petroleum, the silver and the gold, sinews of civilization, under the guidance of science, are being wrested from the dark caverns and gloomy mountains, by the ceaseless throng coming from the overstrained old world, and preparing the way for the new civilization. The application of the microscope to geology promises to be of more value than it has already proved to be in mineralogy, and important as the latter is, we must recognize it as but an introduction; we may hope, ere long, to discern clearly the structural and chemical changes, the alterations of sedimentary rocks, in contact with igneous, under varying degrees of pressure and heat, the all-important and widespread effects of metamorphism, as clearly as though we had, during the geological ages, seen these processes actually going on; and we may learn that catastrophes, cataclysms, and all the varied effects of tension and pressure, are but inevitable sequences of laws whose operation may be foreseen.

What a picture is presented to us in the natural world of what we have seen and still must see in the moral and political world. The glowing fires beneath the vine-clad hills go on with surely increasing strain, while the world of beauty above them, under blue skies, fanned with balmy zephyrs, dreams of paradise. To-day,

> "Far, vague and dim,
> The mountains swim;
> While on Vesuvius' misty brim,
> With outstretched hands,
> The gray smoke stands,
> O'erlooking the volcanic lands."

To-morrow, when the last grain shall be put on to the poised balance, the old shall pass away, and be replaced by a more enduring new. So, in the political world, the volcanic fires of the commune, the metamorphisms of revolution, have, like the great geological changes for the physical world, been perfecting the world of social existence; and, yet, the whole is but the result of the working of long-continued, minute and, in themselves, unrecognized forces. The application of the microscope to the study of rocks, shows to us in the inorganic world that same unstable equilibrium which is the characteristic of life; for, imbedded in the crystal, in cavities so minute

that a thousand to ten thousand millions would occupy only a cubic inch, are imprisoned liquids " which must have been formed under a pressure sufficiently great to reduce not only steam but volatile hydro-carbons and even gaseous carbonic acid to the liquid condition," and which respond in wonderful gyrations to the most infinitesimal changes of temperature and pressure. What a vast field of research and scientific study is here opened before us. We may almost roll back the æons and, face to face, contemplate the operations of those forces that from the beginning have built up not only our own globe, but the whole grand system of which it is so small a part, and comprehend them as though we had been present at the beginning.

But I must not be tempted to digress too far from my theme, the unconscious influence of science studies in moulding the everyday life of a community. We sometimes talk about fashion and the influence of fashion, especially upon our wives and daughters. We hear it said : " Make it unfashionable to drink or to gamble, and our young men would stay away from the saloons and the faro-table, and our daughters from the heated ballrooms and theaters; but what is the influence of ephemeral fashion, compared with that of the teachings of science, felt, seen and heard, every moment of our lives, in the myriads of ways in which we experience them ? Not a hod-carrier climbs wearily up the ladder with his load of mortar or bricks, but is all the better for the electric light, the telegraph, the railroad and the press; better sanitary conditions and better medical treatment make his life bearable, and he has, however slight, some ideas which are helping to elevate him out of the ditch in which his fathers spent their lives, and his children, through the simple avenue of the senses, if not from education, are walking upon a higher plane. As each individual cell of a body contributes its share to the formation, though not controlling it, but in obedience to the sum total of the forces, so each conscious will or purpose is contributing to shape the course of history and destiny of nations, and the minute forces which direct and control here, though not recognized, are nevertheless of the last importance. We have but the feeblest conceptions of "the vast unknown territory that lies back of conscious will and is really the controlling power of life; out of

it things arise and define themselves to our consciousness, and rule our career. Here the influence of environment works; here the elements of race and family; here the time spirit moulds us, and we know it not; here nature, or fate as we sometimes call it, rules us, and makes us what we are. In every people or nation, stretches this deep unsuspected background; here the deep processes go on and here the destiny of the race or nation lies. In this soil the new ideas are sown; the new man, the despised leader, plants his seed here, and if they be vital they thrive and in due time emerge and become the conscious possession of the community."

Looking, then, at the actual condition of society, not as it appears to a superficial observer, but in view of the entire surroundings, calmly, and in the best sense of the word philosophically, we are yet more and more firmly convinced of the Darwinian principle, potent in the intellectual and moral world, as in the natural. "Whatsoever things are good, whatsoever things are lovely," will, in the future, as shown in the history of the past, commend themselves, and become the powerful factors of a better civilization, and the contrast of the world of to-day with that of yesterday is full of assurance of this. We need not, then, trouble ourselves with gloomy outlooks for the future; dark forebodings that where science comes, there religion, and there poetry and art must disappear, and closed forever be the

> "Charmed magic casements opening on the foam
> Of perilous seas, in faery lands forlorn."

While, as scientific students, we must needs be specialists, since so vast is the field open to us and so rapidly extending are its dimensions that the demands made upon us confine us to very narrow fields of labor, we should only be so for the laboring hours. If we turn the microscope the other way, changing but a little, we have a telescope; and a far-off world, of which, as microscopists, we had no conception, lies spread out with its unfathomable depths. The methods of science and those of theology are as diverse as are the microscope and the telescope, and though there is one underlying principle for both, they can never exactly come together without ceasing to be, the one a microscope, the other a telescope,—the one science, the other theology. Nor is it best for us that they

should, or that antagonisms should cease: science is in danger from specialism, and the antagonism of classical studies, metaphysics, theology and art culture, are real necessities for the development of a well-balanced civilization. While nature in itself is not evil but good, and while the study of nature gives boundless scope for the intellectual powers of man, and opens to his imagination boundless visions of beauty, as well as unlimited stores of facts, let us be careful to award to the other means of intellectual and moral culture the due meed of praise. Our statesmen, our theologians, our physicians, and, far more, our artisans and laborers, will ever make the mass of any community; we cannot ignore their lives and their labors; happy indeed, if still, with the advancing civilization, the influence of science be found, like the balance-wheel of the chronometer, though apparently but a small part of the beautiful combination of well-finished wheels and springs, the important part, controlling the motions of the whole with the regularity, almost, of that majestic motion of the heavens with which, always, we must compare it.

And now, in closing, may I be permitted a personal reminiscence? Twenty years, almost, are passed, but the scene is as freshly before me as though it occurred but yesterday. I stand upon the cliffs at Alderney; far off, on the horizon, I catch a glimpse of France, reflecting back the warm glow of a closing summer's day. Away below, I hear the booming, surging swash of the incoming waves of the yet low tide; and now, I am down the steep descent, and clambering over the wet and slippery rocks, rich with piles of seaweeds, full of microscopic life; and as I sit, anon, in one of the dark caverns hammered out in the rocks by ocean tides and currents during a geological age, and muse upon the mysteries of life, so wonderful in the minute algæ that I have gathered, I feel the influence of the environment, and am conscious of its power upon the better half of my own being; and as the day declines, and in the clear blue eastern sky appears a pale, not yet completed disc, I see with mental vision, following in under this, the great tidal wave, and know that soon these limp, but still wet, mosses will float joyously, and spread out their eager fronds in the welcome bath; and I realize that "He hath given them a law which shall not be broken"; and

with firmer trust, but not self-satisfied,—with better resolutions, but not less faith, the exquisite lines of Lowell come home to me, and assure me as they must you, that where Science comes, there Poetry will find her noblest use, there Faith her sublimest exercise.

"The drooping seaweed hears, in night abyssed,
Far and more far the wave's receding shocks;
Nor doubts, for all the darkness and the mist,
That the pale shepherdess will keep her tryst,
And shoreward lead again her foam-fleeced flocks.

"And, though thy healing waters far withdraw,
I, too, can wait, and feed on hope of Thee,
And of the dear recurrence of thy law;
Sure that the parting grace that morning saw,
Abides the time to come in search of me."

PLATE I.

~~PLATE III~~

HELIOTYPE PRINTING CO., BOSTON

THE ACTINIC AND VISUAL FOCUS IN MICRO-PHOTOGRAPHY WITH HIGH POWERS.

JACOB D. COX. LL. D.. F. R. M. S.. Cincinnati, O.

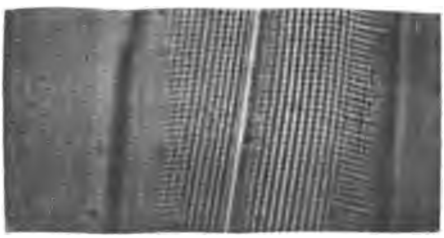
EXPLANATION OF PLATE I.

The figure in the smaller rectangle is printed from a true *negative* of *Pleurosigma balticum;* that in the larger rectangle is printed from the *positive*, as explained in the foregoing paper.

objects photographed, either the positive or negative image would be good enough for the purpose intended: so good that a close examination of the point I am now suggesting would hardly occur to one. This, in fact, was my own experience until, in efforts to get a good picture of the broken edge of fragments of the finer diatoms, my attention was arrested by the fact that the appearances seen by

PLATE I.

~~Plate III~~



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[PLATE I.]

We find it commonly said that whilst the difference between the visual and the actinic focus is considerable when making micro-photographs with low powers, it is not appreciable when using high powers. My experience does not accord with this statement, and some notes upon my own experiments may have interest to others.

If the statement had been that a *sharp picture* may be taken when the object is exactly in focus with a high power, I should not take exception to it, and I incline to think that this is what has been meant. But a sharp picture may be either a positive or a negative of the visual image seen in the microscope, and in my own work so many examples have turned out to be positives when I expected them to be negatives, that I have been led to make an investigation of the subject, in which the evidence tends strongly to show that with our best high power lenses the image fixed upon the sensitized plate is a positive instead of being a negative, and consequently the paper prints from this are negatives and not positives.

It would be very easy to overlook this difference in a large class of micro-photographs, because, in an alternation of dark and light lines, or dark and light spaces, it often matters little which of a pair is light or dark; the picture may be equally clear and satisfactory either way. In the case of a large majority of the microscopic objects photographed, either the positive or negative image would be good enough for the purpose intended: so good that a close examination of the point I am now suggesting would hardly occur to one. This, in fact, was my own experience until, in efforts to get a good picture of the broken edge of fragments of the finer diatoms, my attention was arrested by the fact that the appearances seen by

the eye were often reversed in the print from the supposed negative which I had taken. As, in dealing with minute areolæ this often amounted to showing a projection where I had seen an apparent depression, and *vice versa*, it became in effect a failure to photograph what I had seen, and challenged my best efforts to overcome the difficulty. If the illumination of such transparent objects as diatoms were always by a perfectly central beam of parallel rays of light, there would be no practical difference whether they showed light upon a dark ground, or the reverse. But we rarely get such exactly central illumination, even after our best efforts to do so. For example, plate No. 23 of my broken shell series was thus taken with light intended to be strictly central, a diaphragm being behind the achromatic condenser, which had a small circular hole in it, limiting the illuminating rays to the small central portion of the condenser. Yet in one position the central areolæ of the *Coscinodiscus* which it represents, appear as deep cups, whilst, if the photograph be turned around so as to change places of top and bottom, they appear as projecting bosses.

No. 51 of the same series was the first in which I distinctly marked in my note-book the fact that the dots in that diatom, *Mastogloia angulata*, appeared dark in the instrument, but light in the photograph print. The difference of effect was least important in shells which are an even, smooth film of comparatively little thickness, and greatest in those in which the diatom seems to have strongly marked bars separating the lines of areolæ, as in *Pleurosigma balticum*.

In a number of cases in which the plates were originally taken with a sharp focus upon the view of the shell which I desired, I have taken transparencies from them by contact, and using these last as negatives from which to print the paper prints, I have found that these last are, according to my notes, what the former should have been if there were no difference between the visual and the actinic focus. A few of these have been prepared for exhibition to the Society. The prints taken from the second plates are marked "positives" of the originals, and are in fact the true representation of the object as I saw it when taking the original photograph. They are No. 66, *Navicula serians*, Kutz'g, taken with a Spencer $\frac{1}{16}$

objective, balsam angle 125°, with No. 118 as the "positive" from it.

No. 60, *Pleurosigma formosum*, W. Sm., taken with a Spencer $\frac{1}{10}$ objective, balsam angle 108°, with No. 122 as the "positive" from it.

No. 83, *Pleurosigma formosum*, W. Sm., taken with a Wales $\frac{1}{15}$ objective, balsam angle 82°, with No. 119 as the "positive" from it.

No. 110, *Pleurosigma balticum*, W. Sm., taken with a Zeiss $\frac{1}{18}$ objective, balsam angle 116°, with No. 113 as the "positive" from it.

The accompanying plate gives a reproduction of the last pair.

The objectives are all of the first class, and it is safe to assume that what holds true with them will be found true with any of our best glasses.

In taking the original photographs, I used a plain plate of glass instead of the usual ground glass screen in the camera, and focussed by the aid of a Dorlot focussing glass.

The examples to which I have referred would seem to warrant the conclusion that in using high power objectives the difference between the visual and the actinic focus is the equivalent of that between a positive and negative image of the object when the details have passed a certain limit in fineness. But some experiments, made for the purpose of finding how far the tube of the microscope must be moved to secure the proper actinic focus upon the sensitive plate, have had such unsatisfactory results as make me unwilling to venture any positive conclusion, but content myself with stating the facts above given, until further investigations which I am making shall be completed.

In the course of the experiments referred to, I noticed that the image taken on the plate was apparently of a lower plane in the object than the visual one which I was seeking to get. This was shown in the diatoms with a convex surface, by the sharper image, in the print or plate, of areolæ nearer the margin of the object than those upon which I had focussed. It showed also that the difference seemed to be the same in kind as in the use of low power objectives, with which it is necessary to raise (withdraw) the tube after getting a sharp visual image of the object. Acting upon this, I tried in several instances the gradual raising of the tube, taking pic-

tures at slightly varying departures from the visual focus, until the image was quite spoiled and blurred to the eye. I made some series of as many as five or six plates, thus progressively varying, but without satisfactorily establishing any point (different from the visual focus) at which the objective should be placed to secure in the photographic image the true characters of the visual one. I was surprised to find at what a distance from the visual focus *a* sharp image could be taken, but it was not *the* image for which I was in search. Examples of this sort are among the prints which I will exhibit to the Society.

I design to add to my experiments on the subject the examination of the effect of changing the focus of the focussing glass to correspond with the difference between the visual image of a diatom showing light dots or areolæ and that which shows dark ones. Everybody has noticed that a slight change of focus with a high power produces this change of appearance, and if the focussing glass were adjusted for the image which is complementary to the one desired and then the focussing done in the usual way, the result might be that which is sought. It has at least seemed worth the experiment, but a press of other work has prevented my making a satisfactory test of it before the time of our meeting.

SOME DIATOM HOOPS.

The Question of their Mode of Growth (Aulacodiscus Kittoni.)

JACOB D. COX, LL. D., F. R. M. S., Cincinnati, O.

The hoops of diatoms have such relation to the growth of the frustules and to the process of their increase by division, that a careful study of this portion of the organism will sometimes throw unexpected light upon its general life-history. The mode of growth of the hoop itself presents an interesting question, which, so far as I know, has not been settled. Does the hoop grow by accretions upon the edge, or is the whole formed at once out of the living contents of the frustule? The former of these views has weighty authority in its support, but the latter seems to me more in accord with observed facts and with the recognized principles of vegetable growth. It may fairly be admitted, however, that there are difficulties in the way of either hypothesis, and that the subject is a fit one for careful observation.

The most noticeable difference between the hoops of different species of diatoms is found in the fact that some of them are hyaline, whilst others are elaborately figured and ornamented with markings more or less resembling those of the valves. It seems clear, upon examination, that the figured hoops are generally persistent, forming a permanent part of the diatom structure. Of these, *Isthmia nervosa* and *Biddulphia pulchella* are familiar examples, the same broad hoop remaining attached to the valve through oft-repeated formations of new valves within it as the self-division goes on. This is true not only in those genera which form irregular filaments of frustules adhering by stipital points, but also in the filamentous *Melosireæ*, where the more perfect adhesion simulates a continuous tube or stem.

The hyaline hoop seems usually to belong to the free swimming forms and those closely parasitic species in which a single frustule alone remains sessile upon and closely adherent to a larger alga or other support. In this, as in so many other cases, nature would appear to abhor a waste, even of ornament, and a bare simplicity marks the parts which are cast off after a momentary use.

Some years since I made a series of notes upon the characteristics of the growth of *Aulacodiscus Kittoni*, Arn., which offers an interesting example of the growth, ripening and separation of the hyaline hoop in a species of which the valves are strongly and elegantly marked. The substance of these notes, with some conclusions from them, I shall lay before you.

The normal form of this diatom is a convex disc with four short but large processes, from which run to the center conspicuous double lines of large areolæ, giving to the valve the well-known appearance of being marked with a cross, of which the rays end in the hollow side of the crescent-shaped processes. In the two valves of the frustule these processes are not opposite each other, but are placed alternately; and so long as two or more frustules remain in a temporary filament, they are interlocked by each process fitting into the hollow between those of the neighboring valve.

The hoops are hyaline, and divided by well-defined sutures into five, six, or more parallel bands or rings. These sutures are unusually well marked, the refraction of the light through them giving the whole hoop a corrugated appearance, as if it were considerably thickened over the suture line. This, however, is shown to be a mere optical illusion, by the fact that the hoops slide over each other when the new frustules separate after the self-division of the parent.

The most noticeable characteristic of these hoops is that the sutures are not continuous lines going quite around the shell, but at one place curve sharply upward toward the valve, so that a tooth from the next outer division of the compound hoop cuts through its neighbor. These teeth alternate upon different sides of the shell, so that if it be placed with a series of the teeth toward the observer, they appear to divide only the alternate rings of the hoop; but upon focussing the microscope upon the opposite side of the shell, similar

teeth will be found in the intermediate rings of the hoop (*fig. 1*). If, then, the hoop be divided upon the lines of these sutures, it will be found to be made up of a connected series of imperfect rings or bands with a projecting tooth upon the edge, and with the curved ends of the band separated by a space into which would fit a similar tooth upon the adjacent band of the hoop (*fig. 2*).

Fig. 1

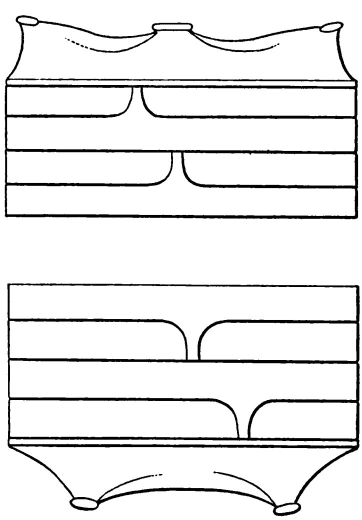
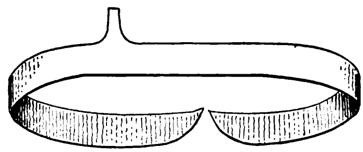


Fig. 2



As the projection of these teeth is toward the valve with which the hoop is connected after the telescopic sliding of the hoops begins, it follows that the teeth of the interior hoop point in the opposite direction from those of the exterior, and before the sliding process begins, the effect, to the eye, is as if each band or ring were doubly sutured into teeth, one projecting toward each valve; for the lines of the division of these bands coincide as to the rest of their extent, and it is next to impossible to tell by direct examination whether a given tooth is in the exterior or interior hoop till the sliding process begins. Then it becomes plain, as I have stated, that the direction of the teeth have a fixed relation to the valve to which each hoop is attached, and uniformly point toward it. The position of the teeth in the several bands or rings of the same hoop are not entirely symmetrical, though they are approximately so.

When the fission of the parent diatom is complete and the two new frustules slide apart, the hoops have ripened so that the sutures between the bands open at the slightest touch. The division of each band by the tooth of the neighboring one, allows it to spring open, and the frustule (or pair of frustules ready for separation) is thus freed from the hoops, which fall to pieces of themselves.

If we examine such a hoop before it has ripened, we find that though the lines of the sutures are perfectly visible, the adherence of the rings is so firm that the whole hoop will break in other places as quick, or nearly as quick, as upon the suture lines. But if we happen upon an example which has been fully ripened, a slight moving of the covering glass or the touch of a bristle will make it instantly separate at the sutures into its half dozen parts lying loosely upon each other in the field.

I think no one can examine this mechanism without being convinced that it is designed to facilitate the escape of the new diatoms from the shell of the old one, and that it points toward this easy escape and separation, just as the broad flanges of the *Isthmia* and *Biddulphia* point to a firm and lasting continuance of the connection between hoop and valve in those genera.

The facts which I have described, seem to me also to bear directly upon the question of the mode of growth of the diatom hoop. If we suppose the hoop to grow (when the sliding process goes on) by the deposition of silex upon the free margin, this would be in a continuous and regular accretion. How then could we account for the sutures, and the symmetrical division of the hoop into the toothed rings which we find? We must bear in mind that the hypothesis must apply to the outer lamina as well as to the inner, and that too, after the separate inner hoop has been formed. If this hoop were itself a multicellular structure, we might think of its growth as of the leaf of a tree; but since the whole diatom is unicellular, it seems to me that we can only conceive of the formation of its walls from the living mass within, and that once the outer hoop, stiffened with silex, is separated from the cell contents by another silicious wall over which it slides, the idea of growth at the edge of this outer wall becomes untenable.

If, on the other hand, we think of the membrane as formed upon the vital contents of the cell itself, as its epiderm, the differentiation of its parts by sutures or by other markings, is in accord with our experience of the formation of vegetable cell walls in general. The growth of an inner one, or the splitting of the wall by intersusception, would also be in the line of our botanical knowledge of other families. The singular stiffening of the walls by the deposit, or

secretion, of the silex which is the characteristic of the Diatomaceæ, would introduce the mechanical feature of its growth by the sliding of the hoops upon each other, but would leave all the other characteristics of vegetable cell growth in harmony with the rest of our botanical knowledge, or at least not in conflict with it. The silex punctuates and makes permanently visible the areolation of the cell wall, but this marking of the wall is in no wise inconsistent with the law of structure in other single vegetable cells.

In the case of *Aulacodiscus Kittoni*, the fact that the teeth formed in the sutures of the exterior and interior hoops point in different directions, seems to me to indicate strongly the formation of successive walls of the cell, each from the live contents of the cell itself, and each having a special polar relation to the valve to which it especially belongs.

I do not overlook the fact that the whole diatom is enveloped in a gelatinous covering, but I see no evidence that this has any vital function to perform from without upon these silicified cell walls. Even if this gelatinous covering be not a mere excretion, it would properly rank only as a soft exterior coat, and the vital processes which determine the structure of the silicified inner wall, would, in every single cell, be most philosophically considered as working from within outward.

The considerations which I thus submit in regard to the diatom I have taken as an example, may be with equal force drawn from the characteristics of other genera of the family. The peculiarities of this shell, however, have not before been fully described, and for this reason, as well as for their bearing on the general question of diatom growth, they have seemed worth the presentation to the Society.

OBSERVATIONS ON SOME FRESH-WATER INFUSORIA.

With Descriptions of a Few Species Regarded as New.

D. S. KELLICOTT, PH. D., F. R. M. S., Buffalo, N. Y.

[PLATE II.]

At the two preceding meetings of this Society I have presented short papers giving some results of my observations on our fresh-water Infusoria. It has been my pleasure to continue the study of these animated atoms, and some of the facts thus ascertained are herewith presented for your consideration and criticism. I regret, more than any one else, that I cannot exhibit the animals themselves with their beauty and activity unimpaired, but they cannot be kept alive for an indefinite length of time, and I have failed in attempts at preserving them, at least, in a manner at all satisfactory. The drawings made to illustrate my descriptions were outlined, in most cases, under the camera, and I trust are truthful and helpful. I have spared no pains in verifying my conclusions by repeated observations; besides, I have often had the benefit of joint examination with my friend Dr. Lee H. Smith, and I hereby, with pleasure, acknowledge his assistance in clearing up many doubtful points. Moreover, I have tried to appreciate the difficulties of this line of study and the hazard in publishing conclusions in a field in which so many able investigators are engaged. In view of this I have been reluctant to name species; as a consequence, several of our characteristic forms have been named by others while I hesitated. In those instances where I have ventured to bestow a specific name I have, as a rule, taken care to state my reasons for regarding the species as distinct; if the reasons are not sufficient the synonyms are the result of error in judgment.

Within the last few years some notable fresh-water Infusoria have

PLATE II.

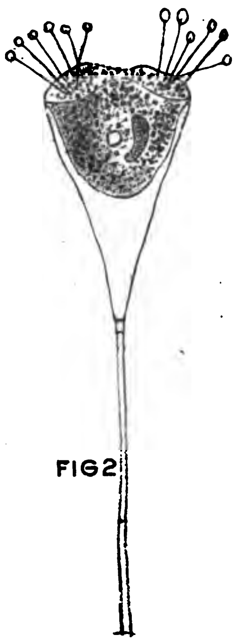


FIG 2

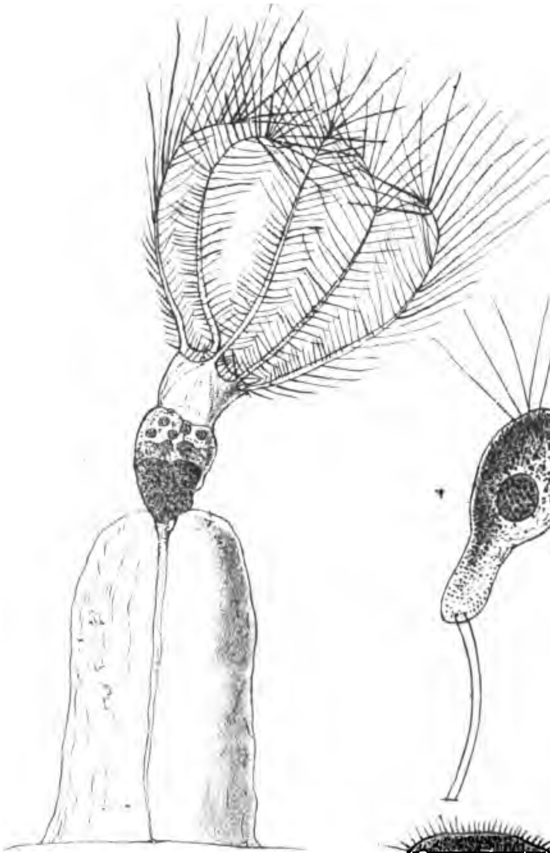


FIG 9

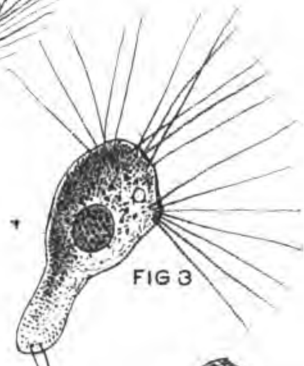


FIG 3

FIG 8

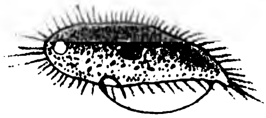
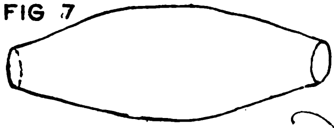


FIG 7



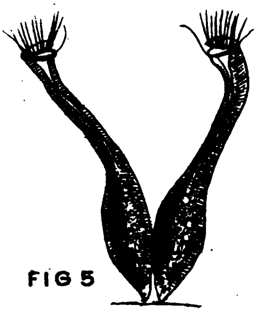


FIG 5

FIG 6

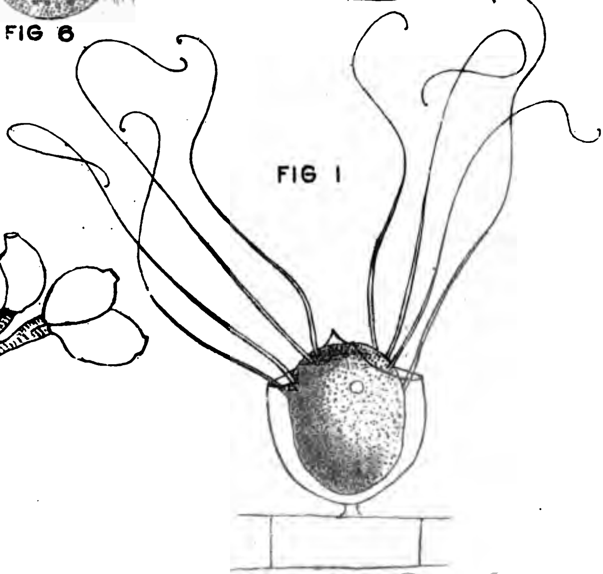


FIG 1

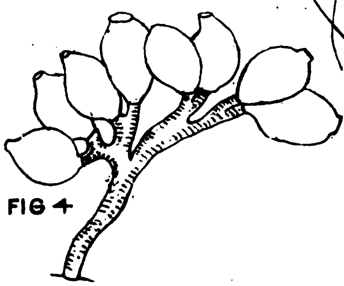


FIG 4

been discovered in this country. For example, *Vorticella vestita*, described by Dr. A. C. Stokes, which is completely surrounded by a cellular, hyaline vesture and, as demonstrated by Dr. Stokes, has two contractile vesicles—a character rarely possessed by a vorticellid. This lovely species I have recently obtained plentifully, attached to *Ceratophyllum*, from Scajaquada Creek, Buffalo. Another recent species of especial interest is *Epistylis ophidioidea* from the same stream, described in *The Microscope*, volume iv., 248. It is one of the most bulky vorticellids known; it is remarkable alike for the unusual structure of the zooids and the luxuriance of the colony growth; but the most noteworthy feature, however, is the two distinct types of zooids; mingled with the hosts of ordinary individuals there are a few strangely modified ones; their bodies are greatly elongated, snake-like in form and motion. The significance of this modification has not been made apparent, it probably has some relation to the reproduction of the species. It has recently been taken attached to aquatic plants in deep, pure water of the Niagara. I never recur to this infusorium without feeling deeply sensible of the inadequacy of my account of it. Numerous other distinct and unique forms could be mentioned, which demonstrate that there is much of deep interest in our fresh-water infusorial fauna to reward research.

I can but think that the species of Tentaculifera are not well represented in the vicinity of my studies. I have encountered a few representatives of this most highly developed group of the Legion, which are not mentioned in the list printed in the Proceedings of the Rochester meeting. The following I regard as worthy of distinct rank and name as species:

1. *Acineta cuspidata*, *n. s.* (fig. 1). The body is spheroidal or sub-cylindrical, not completely filling the lorica and projecting a little above the rim in most examples; the long, flexible, extensible tentacles arising from two opposite sides of the body are few in number and slightly thickened at the extremity. The lorica is hyaline, cup-shaped, with two long points or cusps on the edge, one on either side between the extended arms. Contractile vesicle single. Pedicle short. Height of lorica $\frac{1}{800}$ to $\frac{1}{600}$ of an inch.

I first found the species attached to *Œdogonium* collected in a deep swamp at Point Abino, Ontario, June 7, 1885. To my surprise its tentacles were soon seen to be extending with a writhing,

searching motion like that of the arms of the common Hydra. This beautiful atom, therefore, is closely allied to the marine species *A. dibdalteria.* Subsequent examination may demonstrate that it would be more properly classified with Kent's genus *Actinocyathus.*

2. ***Acineta flava, n.s.*** **(fig. 2). The lorica is triangular, compressed and very finely striated longitudinally. The body is not adherent, usually occupying the anterior half of the shell, in some instances nearly the whole cavity; color yellowish-brown, in young specimens green, parenchyma filled with coarse granules. The two antero-lateral fascicles composed of comparatively few, short tentacles which are distinctly capitate. Contractile vesicle sub-central. Endoplast thick, slightly curved. The pedicle is slender, of uniform diameter, a little longer than the lorica, straight or slightly curved; the lorica is attached to the stalk by a short, flexible piece which permits it to be moved freely back and forth. Length of lorica $\frac{1}{160}$ of an inch.**

This species has been known to those who examine *débris* from the Buffalo water-supply for a long time; it is found free therein in the winter; its color then is precisely that of the very abundant diatom, *Stephanodiscus Niagaræ,* with which it is associated. Recently I have taken it attached to *Cladophora glomerata* from the Niagara; on this support it is sometimes green; the green ones I have taken to be the younger examples. I may not have seen the tentacles fully extended; if so, they are only about half as long as the body. It is an unusually sensitive species. A few taps on the compressorium are sufficient to cause the retraction of the tentacles so that they scarcely appear above the rim of the lorica as short pins stuck into a cushion, and, as it appears to me, under such irritation, when the lorica is made to roll over by motion of the cover, the compressed lorica is still more strongly flattened, the body is then pushed far down towards the bottom of the cup. This acinetan agrees in the outline of its domicile with that of *Grandis,* and also in occupying the anterior part of the same. On the other hand, it is less than half as large as that species. The parenchyma is not transparent and finely granular, but opaque, coarsely granular and colored; the pedicle is relatively much shorter and the tentacles are few instead of numerous. The short, flexible joint by which the lorica joins the stalk is also a feature of difference.

3. ***Podophrya diaptomi, n. s.*** **(fig. 3). Body pyriform, elongate, plastic; parenchyma transparent, with rather coarse granules in the anterior moiety, finely**

granular posteriorly. Tentacles not distinctly capitate, arranged in three fascicles, numerous,—about forty in each lateral bundle,—long and slender. Endoplast spheroidal or ellipsoidal; under high magnification it appears beautifully granular; in younger examples the granules are very much coarser. Contractile vesicle, single, situated near the upper edge of the base of middle fascicle. Peduncle half as long as the body to equal its length, slightly curved, uniform diameter, striate with the body attached obliquely. Length of body, $\frac{1}{100}$ of an inch.

It is found in the winter in great abundance, attached to *Diaptomus sp.* in the Buffalo water-supply. The young are nearly spherical, and their few tentacles are not in fascicles, but irregularly scattered. The animal is usually attached to the body rings of its host, frequently on the upper surface, more often on the under side.

The species is sufficiently distinct from those said to occur on the fresh-water Crustacea.

I have previously reported finding the remarkable Tentaculate, *Dendrocometes paradoxus;* I am now able to report that its near neighbor, and a no less remarkable species, *Dendrosoma radians*, occurs also in waters about Buffalo. I obtained it for the first time in some abundance, and very large examples of it, July 25, on *Myriophyllum* and *Vallisneria* from Scajaquada creek at Black Rock.

In the same collection as the above, *Podophrya quadripartita* was not uncommon, especially on the pedicles of different vorticellids. Among these a number were observed inclosing large, ciliated embryos, one of the forms of reproduction frequently observed by others. These are nearly spherical, occupy the anterior part of the parent's body, between the four tentacular lobes and just beneath the upper or anterior cuticular layer. Below the embryo the endoplast is plainly seen; I was unable to make out that it became striate or fibrilate or in any manner differed from its usual granular character, as reported to do at the time of partition, by Bütschli; several embryos were seen to escape and swim away too rapidly to be followed; a motion of the parent from side to side, reminding one of an alternate shrugging of the shoulders, precedes the exclusion; this action becomes more marked, when finally the ciliated globule, in an instant, passes through the anterior cuticular wall, where there appears to be a specially-formed aperture, and is gone. Those noted as giving rise to young were the variety which is greatly attenuated posteriorly.

In the same gathering there was still another interesting member of this group, viz.: *Acineta mysticinia*, variety *longipes*. The figure of this variety in Kent's Manual represents the pedicle as stouter than it is; in fact, the variety is more attenuate and far more elegant than it is represented to be. I have long known the short-stalked form, and it is not easy to believe that the two are one species. There was a multitude of them on the *Vallisneria*, affording an opportunity to study the motion of the tentacula; the rapid withdrawal and shooting out of these organs were witnessed, but that they were when fully extended capable of flexure in various directions as attested by Mr. F. W. Phillips, I was not successful in demonstrating. Still I may add in this connection that a form, common enough with *Longipes*, which was taken for the young of *P. quadripartita* with two fascicles of tentacles only, exhibited the flexibility of their tentacles in a marked degree, not, however, so much when fully extended as when partly contracted.

Podophrya cothurnata.—I have recently identified this beautiful *Podophrya;* it was taken from a pond mantled with *Lemna*, mingled with *Wolffia*. Our examples accord well with Claparède's figure except that the stout, short pedicle is conical and not cylindrical as drawn by that author. The many contractile vesicles were often seen to collapse all at the same time like the discharge of a "comrade battery;" then slowly to again develop, some faster than others; when all were expanded, another general collapse would follow.

Platycola intermedia, n. s. Lorica ovate, depressed, prolonged anteriorly into an obliquely elevated neck, much shorter than in *P. longicollis* and not funnel form, as in that species, not everted, outline of aperture elliptical, color light brown, attached to Confervæ in spring. Length of lorica $\frac{1}{580}$, $\frac{1}{840}$ of an inch.

I have mentioned and figured the lorica of this species (Proceedings Rochester meeting, A. S. M., page 121, pl. iii., fig. 8); it was regarded as a variety of *P. longicollis*, but on account of its shorter, not funnel-shaped neck, and smaller size, I think it is specifically distinct.

The various species of the genus *Opercularia* are among the most attractive of the Vorticellidæ. The genus is unusually well represented in our fresh waters. I have detected nearly all the described fresh-water forms, besides the following characteristic spe-

cies have been added to the list within the past year: *O. elongata*, *rugosa*, *plicatilis* and *constricta*.

Epistylis cambari, *n. s.* (fig. 4). Body broadest at the middle, slightly gibbous, somewhat attenuate posteriorly and narrowed anteriorly; length about once and a half the width; border thickened, cord-like, cuticular surface transversely striate, under a high power the striæ easily resolved into beads; body of contracted zooid globular with well marked snout-like projection; the ciliary disc is narrow, width little more than half that of the peristome border, conical in form like that of *Umbilicata*; the ciliary wreath is not powerful. Pedicle stout, more or less bent in large colonies transversely striate, usually branching on one side only, or secund; very many zooids in a colony. Endoplast curved more or less nearly vertical. Length of zooid $\frac{1}{600}$ of an inch. On gills of different species of *Cambarus* in the Niagara river.

I read a note on this *Epistylis* at the Chicago meeting of the Society; subsequent examination of it has convinced me that it differs materially from described commensal species, so I have proposed an independent name for it. I have elsewhere spoken of its abundance, I may add that crays dragged up with weeds in mid-winter carried vast numbers of them in the branchial cavity. The disc, which resembles in shape so closely grandmother's tea-pot-lid, allies the species to *Umbilicata*, but the totally different shape of the body and the very different pedicle clearly separate them.

Vorticella rhabdostyloides, *n. s.* Body nearly globular, cuticular surface smooth, peristome border thickened, narrow, cilia relatively stout, endoplast thick, short and but slightly curved. When contracted the body becomes more nearly globular or even depressed until it is napiform. The pedicle is filiform, length about equaling that of the body; length of body $\frac{1}{900}$ to $\frac{1}{800}$ of an inch.

This vorticellid is plentiful during the winter months attached singly to floating diatoms in Niagara-water. It appears to prefer *Stephanodiscus Niagaræ*, which support, if it may be so called, it tows about by the activity of its cilia. I have called it *Rhabdostyloides*, from the fact that the shorter-stalked examples are so reluctant to contract their pedicles; sharp blows upon the cover glass do not always induce this movement; it then has much the appearance of a species of *Rhabdostyla*. The pedice when contracted is thrown more or less into a zigzag than into a coil, as is usual with members of the genus.

The animal is not unlike *R. ovum*, but is more nearly spherical

and very different when contracted with the contractile vesicle more nearly in the center of the body. The peristome-border and pedicle separate it with sufficient sharpness from the only spherical form which it approaches in size.

Gerda sigmoides, n. s. (*fig. 5*). Body very flexible; when fully expanded it is four to six times longer than the greatest width, the posterior third is ovate, tapering nearly to a point, the anterior two-thirds are long, neck-like, gracefully curved, giving the animal a sigmoid outline; the surface is delicately striate transversely; when made to contract strongly by tapping on the cover-glass the body exhibits a few annulations at the extremities; in a few cases longitudinal folds or grooves of the posterior part have been witnessed. The peristome-border is somewhat wider than the "neck" and but slightly thickened; the disc is moderately elevated, slightly convex; cilia normal, vestibular seta distinct. The contractile vesicle is small and situated just above the expanded part of the body. Length of expanded zooid $\frac{1}{180}$ to $\frac{1}{160}$ of an inch. Occurs on Confervæ from ponds.

This very attractive vorticellid was usually seen in pairs as represented in the figure. It was taken only in one pond or puddle from which the water had disappeared by the middle of June. Compared with published descriptions and figures of other species it is clearly distinct.

Spirochona tintinnabulum, Kent. This is an elegant species, an account of which occurs in Kent's Manual of the Infusoria; it occurs in England on the epidermis and branchial appendages of young newts, *Triton cristata*. I am prepared to announce its occurrence in this country on the gills of the young of the spotted triton, *Diemyctylus viridescens*. The cuticle proves to be finely and transversely striated, agreeing with Kent's description rather than with his figure, which represents it as coarsely striate or annulate. I was favored by an opportunity to witness its subdivision by transverse fission as recorded by its describer.

Mesodinium recurvum, n. s. (fig. 6). Body globose, the snout-like process being short; surface smooth; parenchyma inclosing a few large, green granules. At the beginning of the anterior third there arises a cincture of cirrate cilia which are bent backwards extending below the middle third of the body. Above this circle there is a wreath of long, filamentous, oral cilia. Oral aperture in a short anterior prolongation. The single contractile vesicle is situated near the middle of one side of the body. The endoplast is oval, placed subcentrally. Pond-water among algæ; seen thus far only in early spring.

This species in its habits is quite like its relatives. It swims

with the swiftness of *Strombidium Claparèdi* with which it was found associated, and leaps like *Halteria grandinella*, another associate. It darts about the field too rapidly to be followed, until it finds congenial relations for feeding or other pleasure, when it comes to rest, usually standing, with mouth down, and the cirrose cilia stand out a little way from the body so that when one looks down upon it, it is seen surrounded by a formidable *cheval de frise*. When thus apparently feeding it turns on its vertical axis first to right and then to left with a slow motion now and again accelerated until it spins with a velocity that defies the eye to follow.

The close resemblance of this species to *Halteria volvox* of Eischwald one cannot fail to notice, but the absence of the long, straight, springing hairs, and the not eccentric mouth "associated with a spiral or subcircular wreath of long cirrose cilia" separate it unmistakably from *Volvox* and the genus *Halteria*. Nor does it well agree with the terms of the genus *Mesodinium*, inasmuch as it has a wreath of long cilia about the anterior process. But I recall that the same feature has been noted in *M. acarus* by W. S. Kent, and that Claparède and Lachmann have figured *M. pulex* with three bristle-like cirri in advance of the mouth. It is certainly too far removed, if I have correctly made out its structure, from any other genus of the Halteridæ. So for the present I have thought it best to refer it to *Mesodinium*.

Strombidium oblongum, _n. s._ Oblong, nearly cylindrical, rounded posteriorly, somewhat constricted below the peristome region, surface smooth, parenchyma transparent, usually inclosing a few green corpuscles. The oval cirri powerful, half as long as the body; posteriorly several scattered, trailing hairs or gubernacula; these equal in length the body; a few fine cilia on the central part of the body [these may prove to be confined to the ventral surface, as in _S. acuminatum_]. The contractile vesicle anteriorly situated. Abounds in ponds; especially abundant among grass and weeds covered with the mucilaginous _Cœthophora elegans_.

This *Strombidium*, while a rapid swimmer and one that leaps about, when occasion demands it, after the manner of its kind, is after all a comparatively quiet animal; it may remain quietly feeding or slowly moving about its sweet morsels for some minutes, when, if aroused, it will dart away with an energy indicated by its powerful adoral wreath.

Unfortunately, the card containing the sketch and measured dimensions was lost before a record was made in my note-book.

Diplospyla inhæsa, gen. et sp. nov. (fig. 7). This infusorian, which, I think, is new and a type of a distinct genus, was obtained in swamp-water among algæ at Point Abino, Ontario, June 7, 1885. It inhabits a membranous tube open at both ends, and when feeding does not protrude its body from the tube, but gathers its favorite morsels from the water passed through its sheath by the action of its cilia and undulating membrane. In this habit it is unique. Perhaps the tube dweller, *Oxytricha tubicola*, of Gruber has a similar peculiarity, and I cannot but suggest that species may belong in the same genus with the present one, although the latter is by no means an *Oxytricha*. It is a restless creature seldom remaining more than a brief time in any favorable position for study. Its almost ceaseless motion consists in turning over and over, then reversing the motion and finally turning about and reversing the direction of the water current in the tube. It cannot by coaxing or by force be induced to desert its protecting sheath; pressure, stale water and reagents were all tried without success. The only one which I have seen free swimming was a brand new one resulting from subdivision; so my observations were accordingly made through the walls of the membranous sheath, which, fortunately, is quite transparent and usually free from adhering dirt.

Its structure, as I have been able thus to make it out, allies it to the Lembidæ, although at present no representative of the family is a tube-dweller. It is referred provisionally to that group. Its generic characters may be expressed as follows :

Diplospyla. Animalcules inhabiting a membranous sheath, or lorica, which is open at both ends, ovate, elongate, flexible; oral aperture, undulating membrane and contractile vacuole as in *Lembus*.

D. inhæsa. Body ovate, somewhat pointed anteriorly, less than twice as long as broad. The body cilia are rather fine and long. The oval aperture is situated posteriorly to the center of the body; the undulating membrane situated in a groove extending from a short distance back of the anterior border to the mouth; seen from the side, the membrane, when fully extended, appears nearly semicircular; the adoral cilia are stouter than the body cilia situated at base of membrane; posteriorly there are a few setose cilia, apparently without the power of moving. Endoplast ovoid, situated in front of the oval aperture. Contractile

vesicle small, pulsating slowly, near the posterior border. The parenchyma is transparent, sometimes with green bodies that obscure its transparency. Length of zooid, $\frac{1}{800}$ of an inch.

The sheath is hyaline, length $\frac{1}{140}$ to $\frac{1}{180}$ of an inch, contracted at both ends so that the openings equal about one-half the greatest width. Attached by the side to filamentous algæ in swamp-water.

I have witnessed the self-division of the animal which takes place transversely. After the median constriction was first noticed the time required for complete separation was a little more than one hour. One moiety soon escaped from the tube.

One of the associates of this species was the remarkable flagellate *Mallomonas Plosslii*, Perty. It was not uncommon.

Trachelomonas torta, *n. s.* (fig. 8). Lorica egg-shaped, colorless, ornamented by oblique rugosities, giving the shell the appearance of having been twisted. Animal of the usual green color with red eye-spot. Aperture situated in a short, oblique groove. Flagellum very long. Contractile vesicle anteriorly placed. Length of lorica $\frac{1}{600}$ in.

Park Lake, in June, associated with *Phacus triqueter*, *P. longicandus* and many examples of Ciliata.

T. volvocinia is common in ponds and streams about Buffalo. A rarer form, which is a little smaller and has a shell covered with oblique wrinkles, appears to be *Rugulosa.* Mr. C. M. Vorce, some years since, sent to Mr. Henry Mills numerous examples of it, taken, as I understood, from the Cleveland water-supply. *T. hispida* is also known to me. The so-called variety, characterized by a short, anterior, tubular neck, may be *Leguncula piscatoris*, described by Mr. J. H. Fisher, vol ii., Proc. of this Society. I am inclined to think that the latter is distinct; if so, it should be known as *Trachelomonas piscatoris*, Fisher.

A NEW FLOSCULE.

D. S. KELLICOTT, Ph. D., F. R. M. S., Buffalo, N. Y.

[PLATE I., *Fig. 9.*]

For a number of years past it has been my custom to note the peculiarities of such examples of the elegant floscules as I chanced to encounter in my search among the minute forms of pond and stream life. In this way I have become acquainted with at least half the described species*, some of which were not made known until recently announced by Prof. C. T. Hudson as occurring in Britain. The identification of so many of the British floscules in our waters is interesting, as it shows that they are widely distributed; the group is certainly well represented in the waters about my home, and, it appears, by at least one species differing from those so well known in Europe.

While searching for *Stephanoceros Eichhornii*, for the purpose of exhibition at our annual *soirée* Thursday evening, I came upon a form resembling that beautiful creature, but one differing from it so characteristically that I have no hesitation in pronouncing it an undescribed species, and I call it *Floscularia Millsii*, *n. s.* Whilst its elongate form and very long, attenuate lobes without knobs, as well as its attitudes and motions, closely ally it to *Stephanoceros*, yet its structure, so far as determined, places it in *Floscularia* more harmoniously than in *Stephanoceros*, so I have provisionally referred it to the former genus; however, if the young rotifer should prove to have a single eye-spot instead of two it might with equal propriety be referred to the latter, except that, as at present limited, the arrangement of the cilia on the arms does not accord with that genus, for they are not in "whorls of vibratile cilia," but it seems to me that this is a specific rather than a generic character. Subsequent ex-

* This was written before the August number of the Jour. of the Roy. Mic. Soc. came to hand, in which Prof. Hudson describes four additional species of *Floscularia*.

amination may readily change its generic reference to *Stephanoceros;* if so, it will be the second species of the genus. The first species, *Eichhornii*, is also abundant in our ponds and streams.

I have proposed the specific name in honor of my friend, Henry Mills, with whom I am intimately associated as a "tramp"; *i. e.*, I am to him, in the business for which we tramp, a sort of *Fidus Achates*. In fact, this creature was taken from Black Creek, Ontario, where we were together fishing for sponges and other bits of loveliness usually found associated. Thus far the Floscule has been found only in that stream, and in all cases attached to *Utricularia vulgaris*, upon which tube-dwelling Infusoria and Rotatoria were abundant, among which I will stop to mention two, *Stichotricha remex* and *Floscularia campanulata*, both of which were in greater profusion than I had before met with them.

The delicate, sub-cylindrical, gelatinous sheaths of *F. Millsii* are frequently found occupying the fork made by branch or leaf; however, they are often found without this protection; the animal is usually solitary, but sometimes occurs in small groups of three or more. The peduncle is short, as in most floscules; the posterior, attenuate, muscular part is relatively long and terminates rather abruptly in the short, broadly ovate body which is usually brown below the jaws on account of inclosed food; above the grinding organs are usually lodged large, green Algæ, or green infusorians, whose protecting sheaths are apparently too large and firm to allow crushing in the mill. The capacious, hyaline mouth-funnel is but little broader at its free edge than below; the free border is set a very little obliquely. The rim of this bowl bears five extremely long, flexible, tentacle-like trochal-lobes, which are without the least knob-like enlargement at their extremities. These organs are very similar to those of *S. Eichhornii*, except in the character and distribution of the cilia; in fact, they are quite suggestive of the long, flexible tentacles of a polyzoon. The cilia on the lobes are distributed throughout the entire length, fine, longer toward the extremities, those at the ends are nearly half as long as the lobes; they are arranged on the lateral borders of the tentacles and stand straight out, almost reaching those of the adjacent lobes. When the long lobes are being pushed out of the sheath they are held close together in a

bundle; the very long cilia are then shaken out, as it appears, and a shimmer runs over them very much like that seen on the long arms of *F. coronetta* or *F. corunta* when they are unfolded.

The dimensions of a large individual were measured with results as follows: Length from foot disc to body $\frac{1}{45}$ of an inch, length of body $\frac{1}{110}$, length of lobes $\frac{1}{45}$, the total height to top of extended lobes $\frac{1}{15}$ of an inch. Others were measured whose total height did not exceed $\frac{1}{30}$ of an inch.

It is not a sensitive species and very readily displays its ciliary crown when under observation; the usual procession of Infusoria may be seen steadily moving down its throat, nor does it reject Algæ that may be drawn into the vortex.

One, two and sometimes three eggs may be seen in the tube at a time. I have not yet had an opportunity to observe them until they are hatched. This I very much regret, for it would undoubtedly shed light upon its generic affinities and determine whether it is a *Floscularia* or a *Stephanoceros*.

ON IMMERSION OBJECTIVES.

ERNST GUNDLACH, Rochester, N. Y.

It is a well-known fact that the thin glass plate with which microscopic objects are generally covered for protection has a great effect on the optical performance of the objective. But, it may not be generally known that this influence is a highly favorable one if properly utilized. The glass cover is a perfect means of correcting both the spherical and chromatic aberrations of the objective.

The negative flint glass lens of an objective corrects both kinds of aberrations at the same time; but, of both, it leaves the aberrations of secondary or higher order—as I have shown in previous articles on this subject. These aberrations, although much less in quantity than the primary or main aberrations, are rather new productions than remnants of the first aberrations. There are secondary means by which they may be corrected, but here, as well as by the first correction, new aberrations of a still higher order are produced. And this may be repeated *ad infinitum.*

The cover glass is free from this fault; it does its part in correcting the aberrations without producing any new defects. It is, therefore, a perfect means of correction—not because it corrects the whole amount of aberrations, for this it cannot do, but because it does its part in a perfect manner. The influence of the cover glass being thus shown, it follows that the performance of an objective will be less disturbed the greater the part the cover glass is allowed to take, by its thickness, in the correction of the objective. Hence, were the cover glass thick enough to fill the whole space between the objective and the object—which is known as "working distance"—its correcting influence would then be exerted to the greatest possible degree. The optical principle of this is: if the working distance be filled with the cover glass, the light passing through the objective is not refracted and dispersed at the front

surface, while without the cover, the refraction and dispersion of color and, consequently, the aberrations, are great.

On most of our modern wide angle objectives the refraction is greater at this surface than the sum total of the refractions at all the other surfaces of the objective. This, and the fact that the magnifying power is not affected by the influence of the cover thickness, make the importance of the cover as a means of correcting the aberrations at once clear. But, unfortunately, the working distance, which is completely filled by this ideal cover, cannot well be spared; or, at least, part of it is indispensable, as we all know too well. Now, since the correcting power of the cover is due to the refractive power of the material of which it is composed, any other body of whatever nature, but possessed of corresponding optical properties, will serve as a perfect substitute; and, therefore, a homogeneous oil may be used and thus preserve the longest possible working distance while the refraction at the front surface, and all its disturbing consequences, are completely neutralized.

In this we have the principle of the so-called "homogeneous immersion." The object is mounted in a homogeneous medium and covered with a glass circle; the remaining part of the working distance is then filled with homogeneous fluid; it makes no difference whether the cover is very thick or extremely thin; the variation is always balanced by a proportionate amount of the fluid. Although, from an optical standpoint, this form of immersion seems all that is to be desired, its practical application is strongly influenced by the many inconveniences of the different kinds of homogeneous media known at present; and, therefore, for practical work, a fluid that has the least of these peculiar inconveniences may be preferable even should its optical qualities not so completely fulfill the conditions described.

Such a fluid is water. It was for many years past the only immersion medium in general use. The refractive power of water being much lower than that of glass or homogeneous oil, it will, if put in place of those substances, exert a correspondingly smaller influence in correcting the aberrations. But, on the other hand, while the use of the homogeneous medium permits the preservation of the full working distance without any loss in correction, this loss,

if water be employed, can, in a great degree, be regained if so much of the working distance as can be spared is sacrificed and the space filled with glass. This can best be done by adding to the thickness of the front lens, so much that only just enough of the working distance is left as is practicable, and then fill the comparatively small immersion space with water. Indeed, by a skillful balancing of the interfering conditions, the difference between the adaptation of water and homogeneous oil can be reduced to a minimum, and yet the working distance be as long as is practically required.

The high optical superiority of the modern homogeneous immersion objectives over the old water immersion may seem to disprove this theory. But I do not hesitate to claim, right here, that the wonderful performance of these objectives is due, in a comparatively small degree only, to the homogeneous immersion; it is due, in a far greater degree, to the increase of the number of lenses and, consequently, the number of refracting surfaces. We remember that at the same time as the homogeneous immersion the four-system principle was introduced. Probably a more important advantage of the homogeneous over the water immersion, than that of the higher corrective power, may be found in the fact that adjustment for cover thickness is unnecessary. But even this merit is doubted by many first-class authorities on the manipulation of the microscope, and the demand for adjustable, homogeneous objectives is on the increase.

Under such circumstances, weighing its merits and its faults, it must be admitted that the practical advantages of the homogeneous immersion principle are at least doubtful. This cannot be said of the four-system principle. It is unnecessary to enter into a thorough theoretical investigation of this matter. It may suffice to call to mind the fact that the aberrations of higher order are inversely proportional to the number of refracting surfaces. The objection that there is also a corresponding loss of light, although practically true, is of no consequence whatever, as is sufficiently demonstrated by the extensive experience in the use of this class of objectives.

Summing up, we come to the conclusion that the future, high power objectives will be the four-system water immersion. Or, the immersion will be done away with altogether as an incurable inconvenience, and the four-system dry working objective will be used.

POISONOUS DRIED BEEF.

H. J. DETMERS, M. V. D., F. R. M. S., Columbus, O.

[PLATE III.]

Some time this summer numerous cases of poisoning—it is said about sixty, and two of them with a fatal termination—occurred in the city of Momence, on the Kankakee River, in Kankakee County, Illinois.

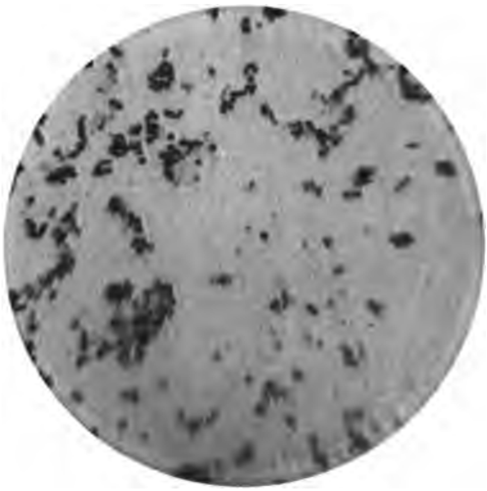
The physicians of Momence and of Kankakee, who were called in, and investigated these cases of wholesale poisoning, soon came to the conclusion that dried beef, procured from one of the Chicago (Jackson street) packing-houses, constituted the cause.

The newspapers, as is usually the case, published every item they could get hold of, and the excitement, not only in Momence, but also in the surrounding country, became very great. Samples of the suspected beef were sent for examination to several chemists and microscopists in Chicago. The reporters of Chicago's enterprising newspapers, ever on the alert when a piece of news can be obtained, soon interviewed these chemists and microscopists, and, obtaining some facts, but probably not enough to make up a spicy article, drew largely on their imagination, and thus inaccurate, and even erroneous accounts were published; for instance, one chemist was reported as having found all possible kinds of Bacteria, *Bacillus anthracis* and *Spirilla* included.

Through the kindness of Dr. H. E. Hildebrand, of Chicago, a sample of the poisonous dried beef was also sent to me. Dr. Hildebrand had obtained the same from a conductor of the E. I. R. R., who had taken it off the breakfast table of one of the poisoned families in Momence, consequently the sample sent me was genuine. It arrived by mail, and was carefully wrapped up in paraffined paper. The sample of beef, thus coming into my possession, was in chips, and of a rather dark color; but as dried beef, even the best, usually turns

PLATE III.

PLATE



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darker, after it has been chipped a day or two, I cannot consider this darker color as something very abnormal. According to the reports in the Chicago papers, Prof. Mariner, of Chicago, one of the chemists who examined samples of the poisonous beef, did not observe any abnormal odor. I did, but find it difficult to describe the same. It was very similar, though not identical, to the odor which usually emanates from certain small, dried fishes (herrings) known as bloaters, and often kept for sale in grocery-stores, when these fish are commencing to become rotten.

My examination, exclusively microscopical, was made in the following way: I took a test-tube, filled it half full with boiled water, then boiled the water in the flame of a spirit-lamp till it bubbled over, and rinsed the test-tube. After that I immediately filled it again about half full with boiled water, closed the opening with a plug of cotton, and boiled the water till about one-third of it had evaporated. Believing water and test-tube now to be perfectly sterilized, or at least destitute of any bacteritic growth, I allowed the water to cool to about 100° F., then carefully, for a moment, lifted the plug of cotton, and dropped into the test-tube a small piece of the dried beef for the purpose of softening the same. Three test-tubes, which I will designate as No. 1, No. 2 and No. 3, were prepared in the same way. After two hours I opened test-tube No. 1, took out the piece of beef and wiped (moistened) with its wet surfaces, several clean $\frac{5}{8}$ in. covers, kept in readiness. These covers, thus wetted on one side, were then treated, stained and mounted in balsam, after Dr. Koch's method. When I passed them through the flame of a spirit-lamp the odor, already described, became very distinct. Some of the covers, or rather the material deposited on their surface, were stained with vesuvine to be afterwards photographed, some with methyl-violet, and some with gentiana-violet. After they had been mounted in balsam without applying heat, I found, on examination, on every slide, innumerable Micrococci, and nothing else—at any rate *no other* Bacteria (see photo-micrograph). These Micrococci are rather large, at least larger than those of swine-plague, and measure from 0.8 to 1.0μ

The small piece of beef, after it had thus been made use of in mounting the adhering Micrococci, was put back into test-tube No.

1, but the plug of cotton was not replaced; consequently the tube remained open. The small piece of beef in tube No. 2 was taken out after it had been four hours immersed; was torn into still smaller pieces, which were placed on clean ⅝ in. covers, and on them teased out with needles. This done, all particles of beef that could be taken hold of with a delicate forceps, were removed, and then the covers were passed through the flame of a spirit-lamp, and stained and mounted in the same way as the others. Result: the same as before, except that the slides contained here and there small particles of muscular fiber, on which transverse striæ could not be recognized.

From tube No. 3 the piece of beef was removed immediately after, or within about four and a half hours after it had been put in. It had become soft, and as it was intended to mount it in substance, it was put between two strong slides, to be squeezed by pressure. The slides were then tied together at each end, and after some staining fluid (methyl-violet) had been allowed to run in between, placed in a bottle with alcohol, and from there, after a few days, transferred to a bottle with turpentine. When sufficiently anhydrated and made transparent, the pieces were mounted in balsam.

When examined, it was found that the muscular fibers had in so far degenerated in this texture (presented a broken-down appearance) as not to show, or to show but very indistinctly, the transverse striæ. Numerous Micrococci, however, could be seen, wherever the same were not hidden by the muscular fibers, but no other Bacteria could be found. I also mounted some of the water in which the beef had been soaked, and which had become quite turbid, but as the result was the same as with the other slides—innumerable Micrococci, here and there a very small remnant of muscular fiber, and nothing else—it will not be necessary to make any further mentioning of it.

Two and three days later some of the fluid, and now very turbid, contents of tube No. 1, to which the piece of beef had been transferred, was mounted on covers in the same way as described. The contents of this (open) tube had become putrid, and had a decidedly offensive smell, entirely different from that first observed. When these slides were examined, various kinds of Bacteria,

namely, Micrococci, apparently identical to those found before, two kinds of *Bacilli*, *Bacterium lineola* and others; in fact, every *Bacterium* of which germs may have been existing in the atmosphere were found to be present, but I was not able to identify any of these *Bacilli* as *Bacillus anthracis*, said to have been found by Professor Mariner.

Professor Long, of the Chicago Medical College, also made an examination, microscopical and chemical, of the same dried beef, and, according to what he told me when I met him in Chicago, the result of his microscopical examination proved to be the same as that obtained by me. He, however, expressed the opinion that some ptomaïnes, which he found in his chemical analysis, constitute the poisonous principle. He probably is correct, but if he is, that is, if the Micrococci present in such a great abundance—thus colonies on the surface of the muscular fibers were visible to the naked eye—do not themselves constitute the poisonous principle, the fact that a great many Bacteria possess fermenting properties, and that Bacteria, very likely, are the producers and developers of ptomaïnes, would go far to show that the Micrococci must constitute the cause (at least the mediate cause) of the poisonous properties. At any rate, it seems to me, the penetrating and characteristic odor developing on and arising from the Micrococci on the covers, when passed through the flame of the spirit-lamp, very strongly points that way.

The question may be asked: Where did the beef come from, or how did it happen to be poisonous? If the newspaper reports on Prof. Mariner's investigations were telling the truth, one might be tempted to conclude that it was derived from an animal afflicted with anthrax, but such cannot be, because in over thirty slides, carefully examined, not a solitary *Bacillus anthrasis* could be found. It is quite certain, however, that the animal, or animals, from which the beef was taken was, or were, diseased, but that disease was neither anthrax, pleuro-pneumonia, so called black-leg or symptomatic-anthrax, actinomycosis, nor any other known epizoötic or enzoötic disease of cattle. Knowing, however, the regulations and prevailing practices in the Chicago stock-yards, and taking into consideration the condition of the beef, the presence of innumerable Micrococci and of ptomaïnes, etc., I believe I am not mistaken

when I say that the beef in question is undoubtedly the flesh of an animal, or of animals, that was, or were, trampled upon in the cars, thus bruised and crippled, and in a dying condition when slaughtered, or of an animal that was killed while in a highly frenzied condition.

Cases of frenzy occur quite often among cattle driven from the stock-yards to Archer avenue, but the health officers seem to pay no attention to frenzied cattle, although they ought to know that the meat of a frenzied animal is sometimes—not always—exceedingly poisonous. So, for instance, there are many cases on record in which venison from a deer, chased to death by dogs, has proved to be poisonous.

Cases in which cattle, and other animals, too, are trampled to death, or nearly to death, in the cars, are very frequent; and still, the health officers, it seems, permit such animals to be slaughtered and to be used for human food. They allow every crippled and bruised animal, if it only breathes, to be hauled through the gate of the stock-yards, and to be carted to the slaughter-houses. But if they espy a steer with a so-called lumped jaw (actinomycosis), a purely local disease, they are very quick in confiscating the animal, notwithstanding that not a solitary instance is on record in which the consumption of the meat of such an animal has been productive of any bad results whatever. On the other hand, cases of swine-plague, unless very conspicuous, are allowed to pass, and no attention whatever is paid to trichinosis, notwithstanding that of nearly 10,000 hogs examined almost 5 per cent., and not a trifle over 2 per cent., as the *late* Commissioner of Agriculture has seen fit to publish, were found to be affected with trichinosis. The percentage might have been found still higher, if the majority of the hogs examined had been aged animals, and not pigs, about a year, or less than a year of age. Further, the most shameful adulteration of other animal products, such as lard and butter, is notorious, and carried on every day on a gigantic scale, and in open daylight, but the health officers pay no attention to it, whatever. By doing so they might offend some of Chicago's millionaires, and that would not do. It is far safer to condemn a steer with a so-called lumped jaw; —it only hurts a farmer.

Another question may be asked, namely: How is it that the meat of a frenzied animal, or of an animal that has undergone great suffering by being trampled upon in the cars, or being chased to death, is sometimes, but not always, poisonous? I think it can easily be explained if it is admitted that the poisonous properties are of a bacteritic origin.

The Micrococci, which I have to accuse as the cause or as the producers of the poisonous principle, are incidental parasites, and not always, and not everywhere present. But if present, for instance, in a dirty railroad car, in a slaughter-house, or in a meat-market, etc., as the case may be, they find an exceedingly fertile soil in the organism of an animal whose tissues are in a congested, bruised, or broken-down and highly feverish condition. For it is a well-known fact that all, or nearly all pathogenic Bacteria, but particularly those which must be classed among the incidental parasites, are powerless to cause mischief unless the animal organism offers suitable conditions for their development and propagation.

SOME REMARKS ON FAT-INFILTRATION OF THE LIVER.

LOUIS M. EASTMAN, M. D., Baltimore, Md.

[PLATE IV.]

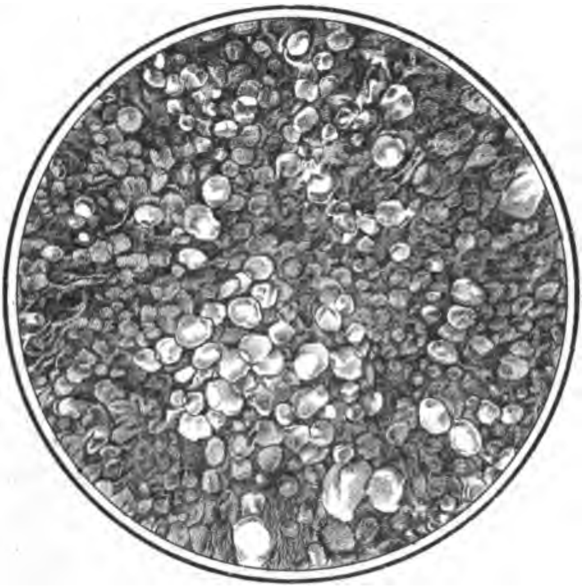
Fat-infiltration of the liver is that condition of the liver in which fat accumulates in larger or smaller drops in the interior of the parenchymal cells, without being caused by a morbid condition of those cells. So frequently does this condition exist, both in health and disease, that the liver has been called the "*Fat reservoir* of the system."

The chemical composition of this fat is identical with that found in the other parts of the body; and its consistence, and consequently that of the liver as a whole, depends upon the relative proportions of the glycerides of stearine and oleine.

Professor Schrœppel, in speaking of the origin of this fat, states: "That it is either brought to the liver cells with the blood, or it originates in the interior of the cells themselves, from the albumen belonging to them." When the albumen thus expended in the preparation of fat is *at once* restored, so that the glandular cell retains its normal proportion of albumen, fat-infiltration is produced; but when this restoration does not take place the cell degenerates into an abnormal condition, and we have what is known as fatty degeneration.

The color of the fatty liver is paler than the normal tint, presenting a yellowish, or greenish-yellow appearance. In size it is either normal or enlarged, whereas, in fatty degeneration, owing to the irreparable loss of albumen, we have shrinkage, and hence the term, yellow atrophy. Although fat-infiltration of the liver is not produced by any abnormal condition of the secreting cell, it is most frequently associated with, or caused by, disease of other organs; indeed, there is scarcely a malady in which the liver has not been found infiltrated with fat.

PLATE IV.



FAT INFILTRATION OF HUMAN LIVER.
AFTER A PHOTOMICROGRAPH BY 1/6 IN. ZEISS & "A" EYEPIECE.

Those affections in which the blood is characterized by the presence of a large amount of fat, and from which we can separate a turbid, milky serum, are those in which the liver most frequently, and to a greater extent, becomes filled with fat.

Preëminently at the head of this list we have pulmonary tubercle, and the drunkard's dyscrasia. In the case from which the specimen I show you was taken, both of these causes prevailed, and hence the so unusual amount of fat-infiltration that I do myself the honor of presenting the following case:

Charles ————, German; aged thirty-two (32) years; saloon-keeper; was of slender stature, wasted form, pale color, and excessively nervous temperament. He had been consumptive for several years, and was very intemperate; beer being the beverage with which he constantly kept himself under the influence of liquor, though he was never seen actually drunk.

A quarrel, in which he became madly excited, was followed by nervous prostration from which he quickly died. At the autopsy, ten hours after death, the left lung and the liver were the only organs presenting an abnormal condition; the former was infiltrated with tubercle, the latter with fat. On removing the liver from the body it was found somewhat enlarged, very plump, of a greenish-yellow color and greasy in appearance and to the touch. The small piece sent me was hardened in Müller's fluid and stained by ammonio-carmine. Owing to the presence of so large an amount of fat the staining was very imperfect, despite the fact that I kept small cubes of the tissue in freshly-prepared ammonio-carmine for more than a month. Better, but still not entirely satisfactory, results were obtained by re-staining the sections in Woodward's borax carmine.

So great is the amount of infiltrated fat in this case that it becomes almost, if not altogether, impossible to define the hepaltic lobule. The interior of the liver cells are found loaded with fat, existing in larger or smaller globules, frequently distorting the shape, and forcing the nucleus from the center to the periphery of the cell.

POLLEN-TUBES AGAIN.

By John Kruttschnitt, New Orleans, La.

[PLATE V]

At last year's meeting of this Society, I presented a paper on the fecundation of ovules in Angiosperms, which was also published in the Proceedings.

The stand which I took was full of perplexities. It was said on one side that the entrance of the pollen-tube into the micropyle of the ovule was the easiest thing imaginable to demonstrate, whilst I, on the other had, after more than twenty years of patient labor and research, have, as yet, not been able to verify the fact. The mystery is now solved.

The most intolerant of my adversaries placed at my disposal a slide of *Capsella bursa-pastoris*, prepared by himself, accompanying it with notes and diagrams designating the spots where pollen-tubes could be seen. The object was prepared by tearing the ovary to pieces, of which the stigma formed one, and the ovary and ovules several other fragments. I easily found the marked spots, but no pollen-tubes. In one instance my attention was called to a certain spot, where it was stated that the "pollen-tubes had pierced the placenta." I discovered here only the stump of a torn-off funiculus, with traces of fibers of the conducting tissue; and again, in another place near a spiral fiber, which he indicated, the traces of some other fiber—but again no pollen-tubes.

The scalpel and needle seem to be generally employed in searching after pollen-tubes. Dr. Carpenter, in his book, "The Microscope and Its Revelations," recommends their use, and so does Mr. Strasburger, in a letter written to me in 1883. I followed this mode at first, but I abandoned it when I found that it produced only erroneous results, inasmuch as the continuity of the tissues are thus

EXPLANATION OF THE FIGURES.

FIG. 1.—Transverse section of ovary of *Cereus Grandiflora*.

a. Micropyle. *b*. Ovule. *c*. Funiculus. *d*. Papillæ on the ventral portion of the funiculus. *e*. Vascular fibre.

FIG. 2.—Apex of one of the lobes of the stigma.

a. Pollen-grains discharging their contents, *b*. *c*. Papillæ on the stigma. *d*. Spiral fibre.

FIG. 3.—Conducting tissue extracted from the style some distance from the stigma.

FIG. 4.—Pollen-grains of a lily in dammar.

FIG. 5.—Pollen-grains in gum arabic dissolved in glycerine. In the former the contents of the pollen-grains are apparently not discharged; the longitudinal markings I consider to be the folds of the shrunken membrane of the pollen-grain, the globules are considerably refractive. In figure 5 the contents of the pollen-grain are discharged through the longitudinal fissure in highly refractive globules of an oily appearance, and scattered over the field of view of the microscope.

PLATE V.

Fig. 1
X 500

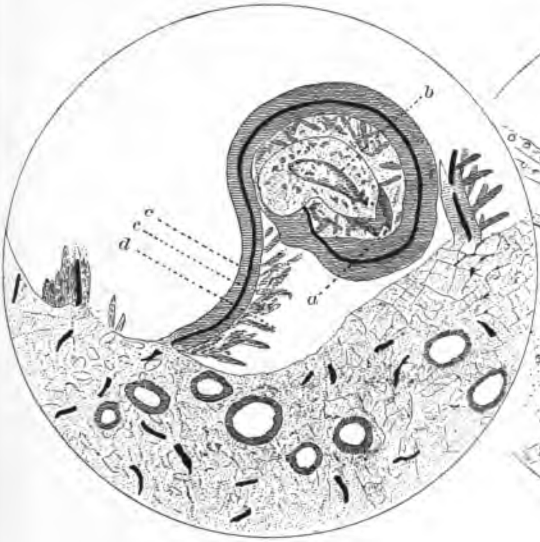
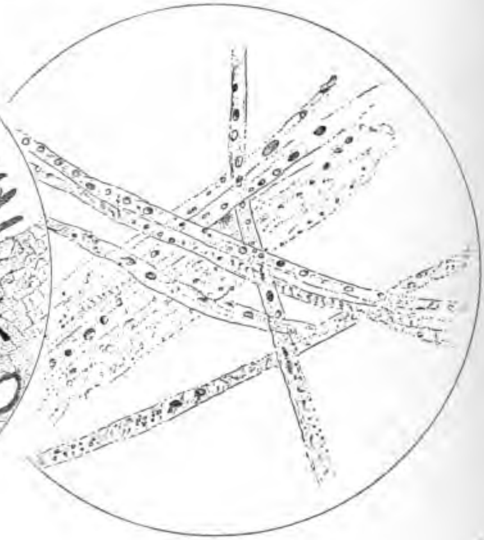


Fig. 3
X 500



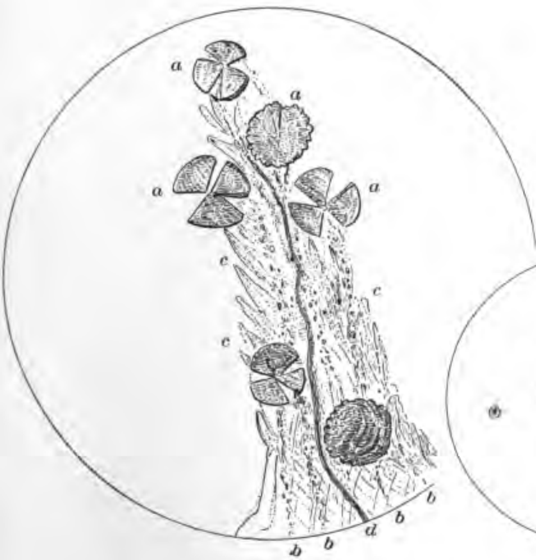


Fig. 2
X 250

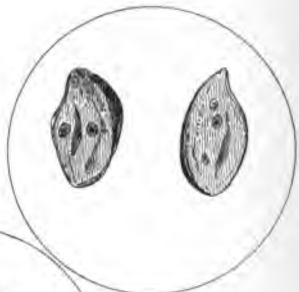


Fig. 5
X 250

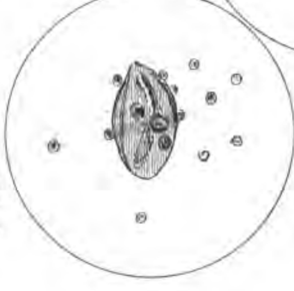


Fig. 4
X 250

destroyed, and it would be strange if, in the process of tearing the ovary, some fibers of the conducting tissue should not be found in contact with the micropyle of an ovule.

The investigators, in their search for separate pollen-tubes, have evidently mistaken the fibrillæ of the conducting tissues for them. According to my opinion these fulfill, in fact, the task attributed to pollen-tubes, inasmuch as they are charged with the fertilizing element contained in the pollen-grain. The discrepancy in the results obtained must be attributed to the different modes of preparation employed and to the fertility of the imagination of the observer.

Mr. Strasburger has recently published a "New Investigation of the Fertilization of the Phænemogams"—investigations which I believe he was induced to undertake by the correspondence which I exchanged with him in 1883. I make the following translation from what he says on *Cereus:* "The pollen-tubes, after treatment with an iodine solution, appear so singularly distinct that even *Cereus* may be recommended as a very good object in which to trace the pollen-tubes in the style. The penetration of the pollen-tubes into the tissues of the stigma of *Cereus* is not easy to follow in their individuality (in den Einzelheiten), but this may very easily be done with *Gramineæ* and *Cyperaceæ*. In *Cereus* the emptied portion of the pollen-tubes becomes so strongly collapsed, and the membranes are so delicate, that it is quite difficult to differentiate them. The pollen-tubes make their descent into the tissues surrounding the stylar canal and not through the canal itself, although such a canal exists."

Mr. Strasburger followed the pollen-tubes into the style only, but did not pursue them further down into the ovary and to the micropyle. He does not say a word about the finely granular matter found in such extraordinary profusion in the conducting tissues of the style, and to some extent in the papillæ on the funiculi of the ovules—and this, notwithstanding that I particularly called his attention to these points in one of my letters in the correspondence heretofore alluded to. He evidently fails to appreciate the significance of the conducting tissue and its functions. I apprehend that if he had done so he would have invalidated his arguments in favor of the existence of separate pollen-tubes.

I have recently repeated my observations on the ovaries of a cactus (*Phyllocactus phyllanthus*) at different stages of the development of the flowers, which are very large. In one of its earlier stages the conducting tissue is easily distinguishable in the style surrounding the stylar canal, which becomes obliterated (or nearly so) near the apex of the ovary. The many lobes of the stigma are very well developed, the ovules are partly so, and the anthers are full of pollen-grains, almost of the same size as in the mature state. In a flower which in a few hours later would have opened, I found pollen-grains adhering to the lobes of the stigma, which, however, disappeared on further manipulation. Some fovilla granules were found in the conducting tissue of the style. I allowed a third flower to expand fully. The pollen-grains adhered strongly to the lobes of the stigma, and, in tearing them away from the style, portions of the conducting tissue came off with them. In these portions the fovilla was seen in cloudy specks and particles, and, by extracting the tissue from the style, the fovilla may be followed down to the apex of the ovary, where it appears to be evenly distributed. The conducting tissue may easily be separated in single fibrillæ, which are tubular, and which, being charged with the fertilizing element of the pollen, may not improperly be called pollen-tubes. In effect, according to my views, by diffusing the fertilizing element over the entire inner structure of the ovary, they perform the functions of the so-called pollen-tubes.

The ovary of *Cereus* contains, according to my computation, at least 3,000 ovules, each of which, it is said, must be fertilized by a separate tube. It accordingly requires 3,000 pollen-tubes to make their descent through the style, and this mass of foreign element in the style—which already contains as much of its normal tissue as it can hold, should be easily discovered. It would also seem as though some of the numerous tubes should be found in the ovary sticking in the micropyle of the ovule. I have, however, thus far not been able to discover anything of the kind.

The process of fertilization in the *Cactaceæ* may readily be demonstrated and made comprehensible to any unbiased mind. In examining a transverse section of *Cereus* many ovules will be seen swinging on their long funiculi, covered on their ventral portion

with many minute papillæ, with which the micropyle of the ovules is brought into natural contact by simply bending over. The papillæ contain granular matter, such as is found in the conducting tissue, which is the fertilizing element of the pollen, and thus the fertilization is accomplished without the help of pollen-tubes.

If the functions which nature has designed for the conducting tissue were accorded to it, the difference between the views which I entertain, and which have been so indignantly denounced by some of the American professors of botany, and the teachings of these professors themselves, would be narrowed down to very small limits. The fibers of the conducting tissue would then, perhaps, be allowed to take the place of pollen-tubes, whose functions, as I have said, I believe that they perform. The former carry the fertilizing element said to be contained in the latter, minus the mysterious pollen-grain nucleus, which is said to occupy the extremity of the pollen-tube, and to the description of the nature and functions of which Mr. Strasburger devotes thirty-four pages of his book.

In the treatment of the pollen-tube question I have now found out that new ideas, not in harmony with established text-books of any science, have a very poor show of finding favor with the professors of that science. It would be an act of self-destruction for any one who aspires to a professorship to proclaim them. If one should do so he would be proclaimed a heretic, and voted out of the congregation. This is the reason why erroneous theories are so difficult to eradicate. Free discussion is not even tolerated. The pollen-tube question furnishes an example. One who has written a book cannot be expected to spoil its sale by proclaiming its errors. As I do not intend writing a book or aspiring to a professorship I have nothing to lose, and I shall, therefore, continue the battle, even should I remain single-handed.

ON THE PREPARATION OF CHICK EMBRYOS FOR MICROSCOPICAL EXAMINATION.

W. P. MANTON, M. D., Detroit, Mich.

The embryology of the domestic fowl, *Gallus domesticus*, offers at once one of the most fascinating and instructive studies within the reach of every possessor of a microscope.

Eggs can be procured at all times, and the reagents, instruments, &c., with perhaps one or two exceptions, necessary to carry on the investigations, are inexpensive and easily obtained.

Very little attention has been paid by the general microscopist to this branch of research; partly, perhaps, because the books on the practical side of the subject are few and expensive. I therefore offer the following brief directions for preparing chick embryos for microscopical examination, with the hope that they may be of service to the beginner, and awaken an interest in this subject.

The necessary reagents are: A 1 per cent. solution of sodium chloride; a 3 per cent. solution of chromic acid; borax carmine; alcohol 70 per cent., 95 per cent. and absolute (Squibs) strength; hydro-chloric acid; spirits of chloroform; oil of turpentine; oil of cloves; Canada balsam; a solution of white shellac in absolute alcohol, rather thinner than glycerine; and paraffine of highest and lowest melting point.

The picric acid solution may be prepared thus: Make a saturated solution of the acid with 100 parts of cold water; to this add two parts of concentrated sulphuric acid; filter, and add to the filtrate three times its bulk of water. To prepare the borax carmine, take 1 pint of 70 per cent. alcohol; one pint of distilled water; three drachms of carmine; and five drachms of borax. These are mixed and cooked over a water bath, and, when cool, filtered.

The easiest way of obtaining embryos for examination is to place

eggs, marked with the *date* and *hour*, under a sitting hen, removing one or more at stated intervals, hardening and placing the specimens in 95 per cent. alcohol for future consideration. The date, &c., should be written on the shell with ink; and it should lie uppermost so that it can be readily seen without disturbing the eggs.

The first egg should be removed after about eighteen hours of incubation, when the first two layers of the blastoderm are well differentiated. After thirty-six hours, the three layers—epi-, mero- and hypoblast,—may be seen. The eggs of forty-eight hours, as well as those of three, four and five days' incubation, should also be treated in the same manner. As soon as one egg is removed from the nest another may be put in its place, and thus, in the course of a week or ten days, a sufficient number of embryos may be obtained to furnish work for the odd hours during many winter months. Older embryos, up to the eighth day, should also be obtained for the study of the completely-formed organs, &c.

The egg to be opened should be carefully removed from under the hen, with the side on which the date is written uppermost, for the embryo always lies on top of the yolk. The egg is then rested on a glass individual salt-cellar, and the shell broken at the larger end to let in air. Then the egg and the cellar should be transferred to a dish of the salt solution which has been warmed to blood heat. The depth of the salt water should be sufficient to quite cover the entire egg. The upper part of the shell must now be broken by a few taps of the scissors or scalpel handle, and the pieces removed with fine forceps over the space the size of a quarter of a dollar. This requires some little care, as the sharp-pointed bits of shell are apt to turn inward and cut the embryo, or open the yolk. When this has been accomplished the embryo will be seen lying within two rings, an opaque one, the *area opaca*, and a transparent one, the *area pellucida*. A circling cut must now be made around these rings with a pair of fine-pointed, curved scissors,—those used by the oculist are the best,—and the disk containing the embryo floated off and washed free of any adherent yolk in the salt solution. While this is going on we must provide a small dish such as a glass sauce dish, with a layer of wax at the bottom. This is quickly done by pouring melted beeswax into the dish and allowing it to

spread out evenly. I have already indicated two hardening fluids,—picric acid and chromic acid. After some little experience with both, I have come to prefer the former, and for two reasons. It renders the specimens less brittle, and they take the stain much better. Therefore, as the chromic acid method is much inferior to the picric acid, I shall give the latter only.

The saucer containing the wax is now filled with the Kleinberg's solution, and the embryo transferred to it on a spatula from the salt water. The edges of the embryonic disc must then be drawn out and pinned down, so that the embryo will harden without wrinkles. For this purpose I like the long, German insect pins, as they are easy to handle and are not readily affected by the acid.

The embryo should be left to harden undisturbed for from five to twenty-four hours, according to size. When this is done, prepare a glass jar,—a half-pint fruit-jar or a tumbler will answer for this purpose,—with 70 per cent. alcohol, in which a piece of cotton floats just below the surface. Upon this cotton lay the embryo, and allow it to remain until the alcohol has withdrawn the picric acid, and the specimen has become whitened. It is frequently necessary to change the alcohol several times before this is accomplished. When the embryo is quite bleached it may be placed in 95 per cent. alcohol for indefinite keeping.

If it is desired to stain at once, the embryo should be placed from the 70 per cent. alcohol into water, and, when washed, into the borax carmine, where it may remain for several hours. It should then be washed again in 70 per cent. alcohol to which a drop of concentrated hydrochloric acid has been added.

After staining, &c., the embryo should be placed in absolute alcohol for several hours. From this soak in chloroform for about half an hour, and then place in a watch-glass containing chloroform and shavings of paraffine. This watch-glass must then be slowly heated, either in a drying-box kept at about 113° F. or in a water bath, until the paraffine is melted and the chloroform driven off. This is done in order that all traces of alcohol and chloroform may be removed, and the embryo thoroughly permeated with the paraffine.

The embryo is now to be placed at one end of a paper cell which has previously been partly filled with melted paraffine and

the latter allowed to cool, and covered with warm paraffine. Should the specimen float out of place it may be returned to any position by the point of a hot needle. And I may say here, that in all manipulations after the embryo has come in contact with the paraffine, the spatulas, needles, &c., used should be kept warm by holding in the spirit-lamp flame; otherwise the specimens will adhere to them and perhaps become torn and ruined. Air-bubbles, which frequently collect about the specimen, should be displaced by a hot needle before the upper layer of paraffine has become hardened.

Before proceeding to cut sections of the embedded embryo, it is necessary to have a sufficient number of glass slides in readiness. These should be perfectly clean and clear. Each in turn must then be warmed over the spirit-lamp flame, and when the mist which collects on the application of the heat, disappears, a glass rod dipped in the shellac solution (already described), must be pushed over the slide in such a way as to leave behind it a thin film of the shellac. If this film turns opaque it indicates that the slide was not hot enough, and in that condition is unfit for use. The film should be perfectly smooth, free from waves, and so thin as to be hardly perceptible. When ready to make sections a slide should be selected, and a thin coating of clove oil given it with a camel's-hair brush, over that portion covered with the shellac film. Care should be taken not to go over the same spot twice, as the oil dissolves the varnish.

A microtome is almost indispensable for cutting embryos; but one used to free-hand cutting with a razor may make very good sections, but with infinitely more labor. The paraffine should be trimmed down to within a few lines of the specimen, and each consecutive section laid on the prepared slide, beginning at the upper right-hand corner and continuing in rows from right to left. In this manner I have been enabled to place 126 sections in good order under a cover glass less than an inch square. The clove oil will cause the sections to adhere to the slide, so that once in place, they remain. When a sufficient number of sections has been placed, the slide should be carefully heated over the lamp flame. This melts the shellac film, permanently fixing the sections. The paraffine is also liquefied, and by placing the slide on the edge it

may be collected to one point. When the slide has cooled, a few drops of oil of turpentine should be poured over the sections to dissolve the paraffine. The turpentine should then be run off, and the glass carefully wiped up to the sections. A drop of Canada balsam and the adjusting of the cover glass concludes the process.

The finished specimen should be labeled, and if a series is prepared, the number of slide and series may be placed at the lower right-hand corner of the label.

Although the above process is apparently complicated, it is really quite simple and easy, and, if carefully carried out, fully repays whatever pains have been taken in its execution.

FIRST DEVELOPMENT OF MUSCLE IN THE EMBRYO OF THE CHICK AND MAN.

BY M. L. HOLBROOK, M. D., New York, N. Y.

Striped muscles arise like other tissues from the earliest indifferent or medullary tissue. It is a well-known fact that in the embryo of the chick the first striped muscles appear in the so-called muscle plates, where, especially in the transverse sections, we have an excellent opportunity to study the earliest stages of their development.

The first thing we observe is that the medullary corpuscles become crowded instead of exhibiting pale fields of myxomotous basis-substance between them. They also increase in size, some of them being as large as colorless blood corpuscles, others are two or three times as large and exhibit indistinct nuclei and nucleoli under comparatively low powers of the microscope. Besides these corpuscles there are also seen, not infrequently, clusters of larger size of a granular mass with a varying amount of nuclei, and in addition small glistening corpuscles between the nucleated ones of a more homogeneous structure and with a higher degree of refraction of light than is usual with medullary corpuscles.

By magnifying this portion of the section of the embryo of the chick about 1200 diameters, the reticular structure of the medullary corpuscle is plainly visible. All the corpuscles are connected with each other by means of threads of living matter traversing the light interstices between the corpuscles. The small granular or globular bodies are also connected with each other and with the neighboring corpuscles in the same way.

The first step towards the formation of muscle is that the points of intersection of the medullary corpuscles become slightly enlarged and arrange themselves in rows vertically to the long axis of the

corpuscle. Sometimes this arrangement into rows occurs first in the nucleus, afterwards in the body of the medullary corpuscle. The rule, however, is that the medullary corpuscle in portions of its body, or in its whole body, takes on this arrangement into rows, whereby the double contour of the nucleus representing its shell becomes transformed into similar granules that pervade the main row and which now deserve the name of sarcous elements. I think I may be allowed to say that this important fact has been settled by my observations.

The truth is, the points of intersection of the reticulum, the so-called granules of the protoplasm, are directly transformed into sarcous elements, and no other change takes place except a slight enlargement of the granules and their arrangement into rows. The delicate threads interconnecting the granules likewise assume a regular arrangement in a longitudinal and transverse direction, interconnecting the sarcous elements both ways. If we bear in mind that the point of intersection and the connecting threads are formations of living matter, the bioplasson formation of Louis Elsburg, we readily realize the transformation of originally irregularly arranged granules into regularly arranged sarcous elements. This was shown in my paper on the muscles of the lobster, read before this Society in 1882, and previously by C. Heitzman.

An increase of nourishing matter will suffice to transform the original granules into rod-like sarcous elements, although not the slightest idea can be given as to why this takes place. As both the nucleoli and the shell of the nucleus are known to be formations of living matter, their participation in the formation of sarcous elements may be understood.

Contractility is a property of living matter in general and it is the same in the medullary corpuscle or in the muscle, only it is more powerful in the latter tissue. As previously mentioned, a number of oblong or spindle-shaped medullary corpuscles may be seen intermixed with the granular one. The previous formations first exhibit the transverse striations, hence the conclusion becomes admissible that globular medullary corpuscles in the process of being transformed into muscle tissue become spindle-shaped. These spindle-shaped corpuscles after assuming the regular arrangement into

sarcous elements, split up into a number of delicate spindle-shaped fibrillæ, groups of which are seen freely mixing with globular and comparatively little changed medullary corpuscles.

As the union between the fibers and the medullary corpuscles is nowhere interrupted, owing to the presence of the delicate threads of living matter between all the concurrent elements, we may understand how a number of fibrillæ may arrange themselves into what we call a muscle fiber, the formerly called muscle bundle. It is highly probable, besides, that the splitting up into fibrillæ is due to the preservation of the specimen in a solution of chromic acid and in alcohol, the latter of which is used to bring out the longitudinal fibrillation more plainly.

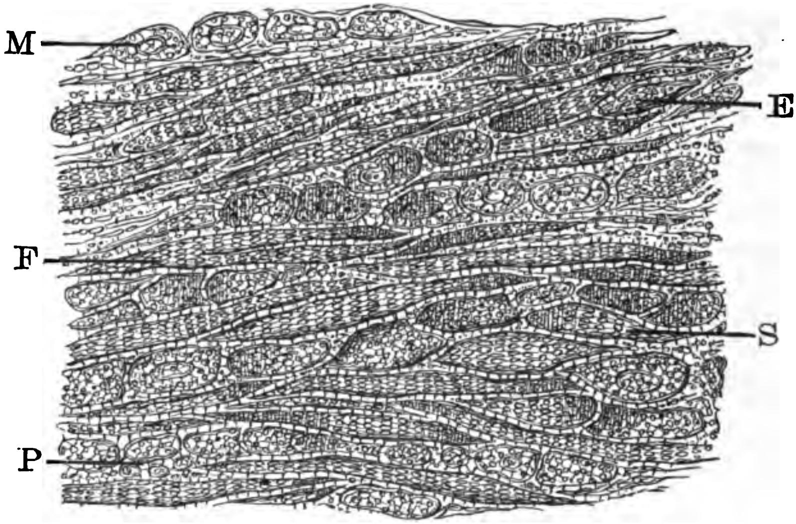
A large number of the nuclei do not take a part in the formation of sarcous elements, but remain unchanged, either at the periphery of a muscle bundle or in its center. The younger the animal the larger the number of such undifferentiated nuclei.

From this regular occurrence a slight deviation may be caused by the fact that sometimes the medullary corpuscles split up into delicate spindles before rows of sarcous elements begin to show themselves. In this way a striking resemblance is established between fibrous cartilage tissue and striped muscle. In the former the reticulum of living matter remains irregular and the meshes are transformed into a glue yielding basis-substance. In the latter the reticulum of living matter becomes highly developed and its meshes contain some nitrogenous liquid substance, perhaps identical with that present in protoplasm in general.

Multinuclear bodies, by becoming elongated, spindle-shaped, split into a number of delicate spindles, and arranging themselves into sarcous elements are directly transformed into the primitive muscle bundles of our early microscopists, or muscle fiber of the present nomenclature.

The same features that I have discovered in the embryo of the chick at five days I have seen in the muscles of the tongue and lower jaw of the human embryo of the seventh or eighth week, but in the third month of the human embryo there are found very long muscle fibrillæ and it is with difficulty that the order of development can be traced.

As to the connection of the sarcous elements both in the longitudinal and transverse sections, it is of interest to note that quite recently two eminent Europeans, histologists, Bremmer and Retzius Key, of Sweden, have confirmed their presence. Thus a certain harmony has been established on this question between American and European microscopists, the former being the original observers.



First formed striped muscle fibers in embryo of chicken after five days' incubation. × 1200. Unstained.

E.—Medullary corpuscle, elongated, the granules being the points of intersection of the reticulum slightly enlarged and beginning to be arranged in rows.

P.—Protoplasm with several small nuclei, perhaps the future perimisums.

S.—Medullary corpuscles, spindle-shaped with distinct rows of sarcous elements—the points of intersection of the reticulum.

F.—Fully developed muscle fiber partly coalesced into one body.

Theodore Margo * was the first to indicate the correct way in which muscle fibers are developed. Previously the notion prevailed, according to Schwann, that each fibrilla is an enormously elongated cell. Margo demonstrated that a number of so-called cells for which he suggested the term sarco-plasts or flesh-formers, through their coalescence, gave the result of what are known to-day to be muscle fiber.

* Denkschriften der Keiserlichen Akademie der Wissenschaften, Band xx., 1862.

Since Bowmann (1849) we know that the longitudinal fibrillæ are merely secondary or even artificial formations. The connections of the sarcous elements, in the earliest stages of formation of striped muscle, and the direct transformation of the granular of protoplasm into prisms of sarcous elements, were not known to any previous observers.

Albert Kölliker,* in the chapter on the development of the muscular system, speaks with great fullness of the morphology and chronology of the development of striped muscle, but I find no mention of its histology or of the histological process of its first unfolding.

* Entwickelungs Geschichte des Menschen: Leipsic, 1879.

STUDIES OF THE DEVELOPMENT OF THE CARTILAGE IN THE EMBRYO OF THE CHICK AND MAN.

M. L. HOLBROOK, M. D., New York, N. Y.

The first tissue formed in the embryo of the medullary tissue is cartilaginous. This fact is acknowledged by embryologists. The process of its development has remained unsettled for obvious reasons. So long as the minute structure of cartilaginous tissue was unknown, no correct idea of its manner of development was possible, and widely different views have been put forward by different observers.

Since the discovery that the basis-substance of hyaline cartilage is not a homogeneous mass but contains much living matter arranged in a reticular manner, the question as to how cartilage develops is very greatly simplified and all previous notions on this subject must be abandoned.

On the fifth day we find in the embryo of the chick all the organs of the thoracic and abdominal cavities distinctly recognizable. On the outer portion of the chest we find beautifully developed cartilage which on account of its regular arrangement must be considered the cartilaginous basis of the future ribs.

To prepare the embryo for cutting and examination we subject it first to a hardening process in a $\frac{1}{10}$ per cent. solution of chromic acid and gradually increase the acid up to about $\frac{1}{2}$ per cent. solution. It is then treated with alcohol for a short time, and now imbedded in celloidin. I used one of the section cutters of Toma of Heidelberg and found it quite satisfactory for obtaining extremely thin sections throughout the entire embryo. I mounted them in glycerine with the surrounding frame of celloidin. In studying the cartilaginous portions of these sections with a power of 500 or 600 diameters the basis-substance appears structureless, and in

most places represents about the width of one and sometimes two cartilage corpuscles. The latter lie very near each other. No trace of territories can be seen, such as are so plainly marked in the hyaline cartilage of grown and growing persons. Neither is there a difference in the aspect of the different portions of the basis-substance as is seen in the grown up animal and so often conveys the idea of a capsule surrounding each single corpuscle.

All the corpuscles in the embryo of the chick appear to be finely granular and most of them contain one central nucleus. Exactly the same features are seen in the embryo of the same age in transverse sections of the nota-chord (*Chorda dorsalis*), the central portion of which has a cavity with medullary corpuscles. If we place the same specimens under a power of 1200 diameters the minute structure of the cartilage corpuscles becomes plainly visible. Whereever a nucleus is seen it exhibits a delicate reticular structure with several larger granules, the so-called nucleoli. The nucleus is also connected with a delicate reticulum throughout the body of the cartilage corpuscle, the points of intersection being generally smaller than those of the nucleus. Sometimes no nucleus is perceptible in the cartilage corpuscle, but a more or less uniformly arranged reticulum, with coarse and fine granules at the points of intersection, pervades its body. Sometimes one or more rows of granules surround the central larger granules, all being connected by threads of a substance of the same color and refraction as the granules themselves. Every single cartilage corpuscle under proper focus appears to be surrounded by a light, narrow rim, and this rim in many instances is traversed by delicate, radiating spokes which originate from the periphery of the cartilage corpuscle with a somewhat broader base. These fine ends point towards the slightly opaque basis-substance enclosing the light rims around the cartilage corpuscles.

The basis-substance itself everywhere appears to be endowed with a delicate reticulum, but its opacity slightly exceeds that of the grayish basis-substance. I emphasize the fact that these features appear in the specimens treated in the simple manner previously described and with the addition of no reagent whatever.

All that is seen is only suggestive of a structure within the basis-substance. To bring this into greater prominence I stained some sections with a half per cent. solution of chloride of gold, first carefully washing them in distilled water. Some of the sections were stained only thirty minutes, others an hour and others two hours. The last proved best. They were very carefully cleansed in distilled water to remove the surplus gold, and mounted in glycerine. Each corpuscle gave a dark violet hue. The basis-substance was

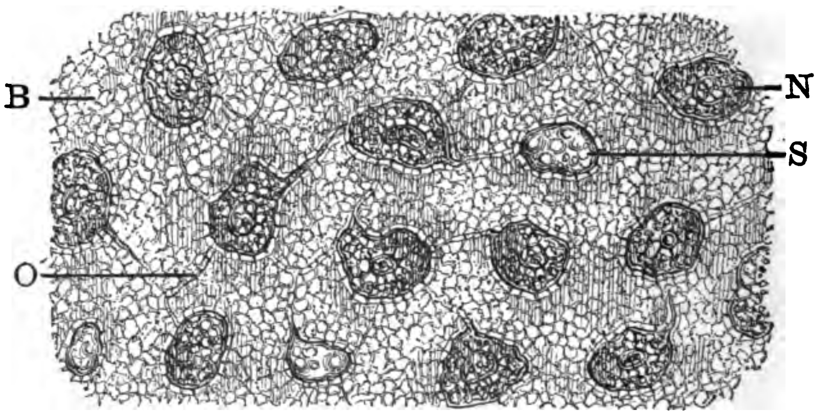


Fig. 1.—Cartilage of rib of chicken after five days' incubation, unstained. × 1200.
N.—Nucleated cartilage corpuscles.
S.—Solid, slightly vacuoled cartilage corpuscles.
B.—Basis-substance traversed by a delicate reticulum, the same as the nucleated cartilage corpuscles.
O.—Boundary line between previous medullary corpuscles that have been transformed into basis-substance.

paler but of a most beautiful violet pink and showing plainly the spokes of living matter emanating from the corpuscles themselves and penetrating the basis-substance.

Since we know that it is the living matter which becomes violet upon being treated with chloride of gold, it is fair to conclude that the cartilage corpuscles and basis-substance are traversed by living matter arranged reticularly; the difference between the two being that living matter in the cartilage corpuscle is more compact and coarse, that is, the basis-substance more delicate, more uniform and with slightly wider meshes which are filled up with the basis-substance proper.

I have traced the same features in the cartilaginous fields of the human embryo four weeks old, the chest of which was cut into horizontal sections. In a vertical section of the facial region of the human embryo six weeks old, the lower jaw cartilage was studied. This represented what was termed the primordial cartilage by Merkel, from which the jawbone is known to arise. The appearance of the cartilage was somewhat different from that of the embryo of four weeks, the cartilage corpuscles being nearly double the size and

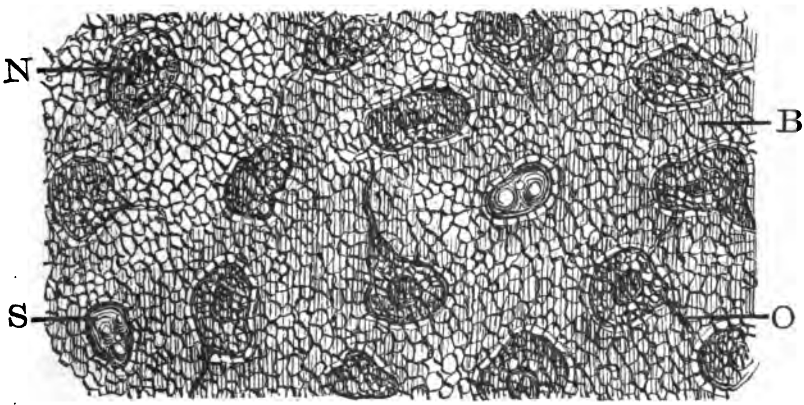


Fig. 2.—Cartilage of rib of chicken embryo after five days' incubation, deeply stained with chloride of gold. ×1200.

N.—Nucleated cartilage corpuscle.

S.—Solid cartilage corpuscle, slightly vacuoled.

B.—Basis-substance traversed by distinct reticulum, the same as the nucleated cartilage corpuscles.

O.—Boundary line between corpuscles that have been transformed into basis-substance.

standing apart at almost uniform distances. Where calcareous depositions had taken place in this specimen, the depositions were invariably seen first along the borders of the territories between the corpuscles. Even in advance of the deposition of lime salts, the first outlines of the territories were distinctly traceable by grayish lines. The calcareous deposits appeared in the shape of highly glistening granules, first in a single row and afterwards in broader trabiculæ, while the cartilage corpuscles are apparently enlarged and split up into medullary corpuscles, the well-known stage preceding ossification.

In the six-weeks human embryo the first traces of bone tissue are

seen at the borders of the primordial cartilage, obviously springing from it. The same stage of calcification of cartilage along the boundaries of the territories, with transformation of cartilaginous tissue into medullary tissue and the first stages of bone tissue springing therefrom, is easily traceable on the condyles of the shaft bones of a chicken six weeks old.

From what has been said in regard to the amount of basis-substance present in the cartilage of a chick embryo five days old and of a human embryo four weeks old it will be seen that the first formed cartilage is not identical with that of a somewhat older embryo. In the first case the distance between the single cartilage corpuscles being about the same as the diameters of the corpuscles, we may, I think, infer that here only single medullary corpuscles have taken part in the formation of basis-substance. We may understand the formation of such cartilage by assuming the transformation of single medullary corpuscles into basis-substance on the same plan on which the first medullary or myxomotous tissue is formed. Later, evidently after the first-formed cartilage had again returned into its medullary condition, a more perfect cartilage tissue is formed by the participation of several medullary corpuscles in the production of a single territory of cartilage tissue. This later cartilage, after the calcification of its basis-substance and its return to the medullary condition, yields bone tissue, although never in the way of direct transformation. In all cases the medullary corpuscles are transformed into basis-substances and do not perish at all, but the liquid contents of the meshes of their reticulum is transformed into the more nearly solid light-refracting substance, while the reticulum of the living matter itself is still present, but less visible, or is even invisible, except to a trained eye. When, however, the section has been stained with chloride of gold, this structure becomes conspicuous. The medullary corpuscles are connected with each other by the reticulum of living matter not only in their myxomotous condition, but after they have been connected into cartilage. Neither in the medullary nor in the cartilage tissue are there any isolated unconnected cells. It is the presence of living matter in the basis-substance of cartilage which enables us to understand the breaking down of both cartilage corpuscles and basis-substance into

medullary corpuscles, a sort of rejuvenescence which is admitted by good authorities and which leads at last to the formation of bone tissue.

The literature of this subject is abundant, but very few data are acceptable from our point of view. M. Foster and F. M. Balfour do not claim to treat in detail of histological changes which take place in the development of the embryo.* Albert Kölliker says: "The histological processes in the formation of cartilage are very simple. First, on all places that are to become cartilage the cellular elements increase in number and the parts under consideration become more dense and less transparent. Next, between the cells appears, at first scanty, later more abundant intercellular substance whenever the elements themselves become enlarged and transformed into light vesicles whereby the tissue becomes lighter and lighter and the cartilage is formed." †

On page 414 Kölliker indicates a somewhat different view and says: "From place to place a portion of the indifferent cells that form the external chorda sheath become differentiated by the formation of a homogeneous intercellular substance, and by increasing in amount it is changed into cartilage tissue. So long as the secretion theory was held by histologists, the process of the formation of cartilage was apparently very simple. The original medullary corpuscles produced a sort of secretion which became the basis or intercellular substance, and medullary corpuscles now became cartilage corpuscles."

Max Schultze in 1861 first pointed out the origin of basis-substance from previous medullary corpuscles. E. Brücke likewise in 1861 maintained that the peripheral portion of the cartilage corpuscle was transformed into basis-substance, while the central nucleated portion remained protoplasmic and took on the features of the cartilage cell proper. As early as 1867 C. Fromman recognized some structure in the basis-substance which he describes as follows: "The intercellular substance of the cartilage exhibited a finely granular structure, looked in some places as if dusty, in others be-

* Elements of Embryology: London, 1883, page 270.

† Entwickelungs Geschichte des Menschen: Leipsic, 1879, page 439.

sides the granules were fibers of great delicacy. These fibers were short and run in all directions." *

This description, though imperfect, plainly shows that to Fromman is due the first suggestion of a reticular structure in the basis-substance.

Later, C. Heitzman,† by means of reagents, mainly the nitrate of silver and chloride of gold, also by the study of the process of the calcification of the cartilage in normal and pathological conditions, came to the conclusion that the basis-substance of cartilage was endowed with a reticular structure, in all essential points identical with that of the cartilage corpuscles themselves. The reticulum is claimed to be the living matter proper, thus maintaining the properties of life for the basis-substance as well as for the cartilage corpuscles. He corroborated the views of Max Schultze with regard to the formation of basis-substance in general and that of cartilage in particular. According to him, the medullary corpuscles, upon being transformed into basis-substance, do not perish, but only the liquid portion held in the meshes of the reticulum becomes transformed into a comparatively solid and the light, highly refractory basis-substance, while the reticulum remains unchanged, simply becoming invisible.

That the basis-substance is endowed with properties of life has been, later, proven by Arnold Spina and by Stricher of Vienna, and Louis Elsburg of New York.

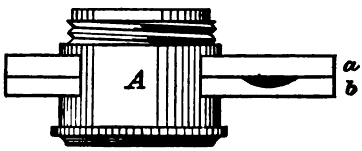
* "Untersuchen uber die Normale und Pathologische Anat., des Ruckenmarks, Zweite Theil, page 30.

†Untersuchungen uber das Protoplasma, Sitzungs Berichte Wiener Akad. d Wissensch., 1872.

DEVICE FOR TESTING REFRACTIVE INDEX OF IMMERSION FLUIDS.

H. L. SMITH, LL.D., Hon. F. R. M. S., Geneva, N. Y.

In testing any medium for immersion purposes with the simple apparatus I am about to describe, but little more than a drop of the liquid is required, and the slightest variations of refractive index are indicated by a considerable latitude of motion, when in the ordinary use of the wedge, as furnished by Zeiss, these variations would be almost or quite inappreciable. The instrument is used upon the microscope, and a reference to the figure will make the application plain. *A* is an adapter about three-fourths of an inch in length, with the society-screw outside and inside. This is attached to the microscope, and carries a one-inch objective. Two slips of crown-glass, *a* and *b*, are taken, which are as near the refractive index of the cover glass as possible, two inches long and half an inch wide, each about a tenth of an inch in thickness. In one of these, *b*, near the end, a concave is ground to a depth of about one-third or more of the thickness of the glass, and polished. To test whether a medium has the same refractive index as the glass, and also the dispersion, a drop of it is put into the concave, and the two slips of glass are placed together and inserted into an opening cut in the adapter-tube, as shown in the figure. A thin stratum of the medium will flow between the two slips. The whole being now in the position shown in the figure, the one-inch objective is screwed on below, and the microscope is focussed on some well-defined object on the stage. Looking through the two slips in this way the focus will be found not to differ appreciably from what it would be if the glass plates were removed.



When the object is clearly defined the plates are pushed in, bringing the concave, filled with the liquid, directly over the back of the objective; if the medium be optically homogeneous with the glass slips, there will be neither spherical nor chromatic aberrations produced, and the definition or focus remains unchanged. As none of the immersion media now known are strictly homogeneous, but may, nevertheless, have the same mean refractive index as the crown-glass, clear vision with these will be obtained with the general focus unchanged, but an excess of color will fringe the outlines of the object. If the focus has been obtained by means of the rack and pinion, the fine adjustment always remaining the same, one can readily ascertain the refractive indices of various media proposed for use with immersion objectives in the following way: Let a mark be made on the rack-bar, or sliding tube, as the case may be, when the focus is obtained with the plates in the position shown in the figure; this mark will indicate, for example, a refractive index of 1.52. Filling the concave now with cinnamon oil, and focussing again (using the same object, objective, and eye-piece), we get another position for a mark indicating refractive index of 1.6. Using water, we get still another, 1.33, and with glycerine 1.41, the extremes will be about half an inch apart, as measured on the bar or tube, and, by interpolating, we can thus get pretty nearly the refractive index of any fluid medium. I have found the so-called homogeneous media sold in the shops to differ very greatly, fully one-fourth of an inch out of the way in many cases. A specimen of cedar oil from Zeiss caused a change of focus only about $\frac{1}{20}$ of an inch, which was less than was required by any other samples I have tried.

When one has a fine objective, and with a given immersion medium has obtained certain positions of the screw-collar for the best work on certain tests, the exact refractive index of the medium can be ascertained, and afterwards always secured. A non-adjustable immersion objective, a $\frac{1}{8}$ by Spencer, which performed most admirably, both with oblique and direct light, with the medium furnished by the maker, showed but indifferently well with another medium, which, on being tested with the little apparatus above described, required an alteration of focus necessary to obtain distinct vision, or rather the most distinct vision, of fully $\frac{1}{4}$ of an inch. On

diluting the second medium to bring it to the same index as that sent out by the maker, the performance was entirely satisfactory. It will be understood that there should be a diaphragm in the adapter of such size as will prevent any light passing through when the concave is put over the objective with the immersion fluid to be tested in it, except what actually passes through the fluid.

MOUNTING MEDIA OF HIGH REFRACTIVE INDEX.

HAMILTON L. SMITH, LL. D., Hon. F. R. M. S., Geneva, N. Y.

At the Rochester meeting, last year, I described, as published in the Proceedings, a medium of high refractive index, for mounting diatoms, especially tests: a compound of arsenic and antimony. I regret to say that nearly all the mounts that I have made in this medium have "gone to the bad," only about half a dozen remain unchanged; some of these are two years old, and one has never had a protecting ring, the mount being under an irregularly-shaped cover. I mentioned, at that time, that I was not ready to make known the composition of a still higher refractive medium, with which I was yet experimenting. I did not choose to say much about it until I was satisfied I could make permanent mounts, or at least had done the best I could with it. In this reticence, or rather, reluctance "to rush into print" (for I did make the whole known to several microscopists), I have been taken to task by the editor of the *Journal of the Royal Microscopical Society*, and some scarcely courteous insinuations were indulged in. I care as little for these as any one possibly can. I have not been influenced by them to say something before I was ready to say it, or had fully made up my mind what to say; nor did I care to take the chances of having some one else develop the process, and have it published as a well known old English discovery, sharing the fate of the "vertical illuminator" now advertised everywhere as "Beck's," when the first one ever seen in England was shown to Messrs. Beck & Powell, sent over by me for this purpose. Both of these gentlemen took out patents for what they deemed an improvement, a glass reflector, which was really what I had used in the first form in which I had made it, as fully described in *Silliman's Journal*, and had abandoned as inferior to the metallic reflector. I may remark that Powell &

Leland made a handsome recognition of my connection with this invention. My experience with this, and some other similar experiences, has made me cautious, perhaps wrongly; and while many friends, and among them Dr. Van Heurck, have been working with the new media, and kept fully informed of my own experiments, I have not hitherto been ready to publish anything, and especially as I was reserving what I might have to say for presentation here.

I have entirely abandoned the arsenic-antimony medium, and think I have discovered another much better one, which gives quite colorless mounts, is much cheaper, and more readily made. I will give the formula for this:

A stiff glycerine jelly is first made, about the consistency of honey, by dissolving clear gelatine (Cox's, or, the so-called photographic gelatine) pure glycerine, by aid of heat, and, in two fluid drachms of this, forty grammes of pure stannous chloride are dissolved. The solution is easily effected by a little heat. When this solution is made it will probably be somewhat milky, but by boiling it in a test-tube it will become beautifully clear, and about the color of balsam. This boiling must be done in a test-tube not over $\frac{1}{4}$ full, as the bubbles are, towards the last, very large, and thrown violently up and liable to eject the fluid from the tube; but with care the whole may, in a short time, be made not only clear, but, when cold, about as stiff as thick balsam; and, if in a small vial, it is not readily poured out. This medium should be used in making mounts precisely as balsam is when the mounts are to be finished by heating. The bubbles escape very rapidly and easily, but towards the end of the boiling, as the medium becomes viscid, they are inclined to persist, but by carefully heating, using a small flame, they will disappear, and, indeed, as they are mostly steam, they will frequently disappear wholly in cooling, when a balsam mount under the same circumstances would be full of bubbles.

If the boiling has been sufficiently prolonged, the cover will be found to be pretty firmly attached, when the slide is cold, and the excess of material can be cleaned off without danger to the mount—indeed, this excess should be hard, requiring a knife or a sharp edge to remove it. It is advisable to put on only so much of the medium as is necessary to fill in under the cover, and have no cleaning to do

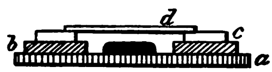
afterwards; in other words, put on a minute drop, and if that should not be enough, feed in a little more from the end of the small glass rod used for dipping. The best thing to clean off the excess is hydrochloric acid—a bit of tissue paper rolled up and moistened with this, not too wet, serves the purpose admirably, but water may also be used, and is nearly as good.

As the medium is deliquescent, it is necessary to use a protecting ring. For this purpose, after the slide is well cleaned around the cover glass, and warmed to dry it, apply a good coat of zinc-white cement, or shellac, colored to suit the fancy. If the sealing is perfect there will be no change by time. It is recommended, however, to use a wax ring. These rings, punched out of sheet wax, of such size as to cover the edge of the thin glass, are put on the mount when it is finished, and, by cautious application of a small flame, just melted, *but not so as to run.* If any bubbles form under the ring, they may be removed by touching with a hot needle or pin-point before the wax cools. A mount made this way will stand indefinitely; it will bear any amount of rubbing, and may be polished by friction with the palm of the hand, and can, at any time, receive a supplemental colored ring of shellac or other varnish for a finish. *Amphipleura pellucida* is very beautifully shown in this medium, and the various Pleurosigmas—indeed, all diatoms except the very coarse ones, which appear almost black in the medium. A very little experimenting will enable one to use the medium successfully.

The use of the gelatine is only to give such a hold upon the cover as will permit the necessary pressure in cleaning. Many mounts have been made, both by myself and others, in the earlier experiments with this medium, without the gelatine, but in all these cases the cover was less firmly attached to the slide. If the protecting ring keeps out moisture from immersion media, or the atmosphere, the mounts will remain unchanged. As the medium dissolves gelatine, albumen, etc., arranged diatoms must be fastened to the cover by heating the latter, supported on a bit of thin sheet-iron or platinum, nearly to the melting or softening point. A larger proportion of the stannous chloride can be dissolved than that mentioned above, even as much as sixty grammes, but then, on heating to

harden the mass, crystals will appear; the crystals never give any trouble when forty to fifty grammes are used.

The second medium, which is the well-known yellow one, is realgar (the transparent sulphide of arsenic), dissolved in bromide of arsenic by aid of heat. Both of these substances should be pure, and the mount should be boiled as long as bubbles are readily given off, by the application of considerable heat, and when cold the cover should be more firmly attached than with balsam. These mounts are of a deep lemon-yellow color, and the compound has a refractive index of 2.4. Excellent, and even better mounts, as to permanence, may be made by sublimation. A bit of the realgar is put on a plate of mica about one inch square, and thick as a penny. This is melted by strong heat of a spirit-lamp. On this mica plate is placed another, with a hole $\frac{5}{8}$ of an inch in diameter, and above this a thin glass plate with a hole slightly less than the glass cover on which the diatoms are mounted. In the figure, *a* and *b* are the two mica plates, *c* the glass plate, and *d* the cover, with the diatoms facing the realgar.



The whole is now supported on a metal ring. A strong heat will volatize the realgar without change, and often a clear deposit is made all over the diatoms and under side of the cover, and the latter can now be mounted in balsam; but, if bubbles are formed in the operation, as probably will be the case, the heat must be continued till these disappear, and, as the deposit will now be thickest at the center, just over the realgar, the mount may be finished by putting the cover, realgar side down, on a clean slide, and on top of it, to prevent breaking, a piece of thick glass, and then, grasping tightly with forceps to give pressure, heating strongly over a spirit-lamp. The realgar will soften (it must not be boiled, else bubbles will form which cannot be removed) and spread out, more or less, between the cover and slide, making a nice, clear mount. The color of the heated realgar is very much deeper than when cold. Instead of the solid realgar, which is liable to crack on cooling, a drop of the solution in bromide of arsenic may be used, but in this case it must be boiled to expel the most of the bromide, before the cover is placed above it; the solid compound now melts at a much lower temperature than the realgar alone. These mounts

will not change, but those made from the solution, directly, will, if the ingredients are not entirely pure, containing no excess of either sulphur or arsenic.

Dr. Allan Y. Moore is an independent discoverer of the value of realgar as a medium for test-diatoms, though, owing to its high melting point, he has not been able to make satisfactory mounts with it. I am informed by Dr. Van Heurck, to whom I gave the formula some time ago, that, with materials prepared for him by Rosseau, of Paris, he had no trouble in making excellent and permanent mounts. As bromide of arsenic will dissolve both sulphur and arsenic, there is always danger, if the realgar is not pure, that there will be an excess of one of these, and if so, the mount will either crystalize or granulate. I had great difficulty in getting the realgar; indeed, it could not be found in New York, and I was obliged to make it; but I have recently received a pretty large supply, purified by sublimation, from Rosseau, Paris, and also of the bromide of arsenic, and shall be glad as long as any remains to share it with any one desiring to experiment.

NOTE.—Since the preceding was writen, I have found that bromide of antimony may be added to the forty gramme solution of stannous chloride in considerable quantity, thereby increasing the refractive index nearly to 2. If too much should be added so that crystalization occurs in cooling, or by long standing, a slight addition of the forty gramme solution will remedy this. The bromide of antimony alone, dissolved in the glycerine jelly, makes a medium of still higher index, and seems to work very well; of course it is brought as near to saturation as possible.

AN IMPERFECTION OF THE EYE, AND TEST OBJECTS FOR THE MICROSCOPE.

By LUCIEN HOWE, M. D., Buffalo, N. Y.

My object in this short communication is to call attention to the fact that fine, parallel lines, whether drawn artificially or existing in natural objects, do not make fair test objects for the microscope. This is caused by an imperfection very common in our own eyes. In order to make that clear, I would call the attention of the Society to the formation of the image of any object on the retina of the eye. It is well known that this optical instrument is constructed like the camera obscura; anteriorly there is a lens, and at its focus a part upon which the image is received. Theoretically, the lens should have a perfect spherical surface, and therefore the image should be equally well defined in all its parts. With the camera obscura this is often the case. In the human eye, however, the lens has its power augmented by a refracting surface, called the cornea, which lies in front of it. When the type of perfection is attained, this cornea and lens have perfect spherical surfaces, and, therefore, the focus which they form upon the retina is equally distinct in every direction, vertically or horizontally. Practically, however, this type of perfection is seldom or never attained. The imperfect curvature is usually found in the cornea; instead of being a section of a sphere, it is more curved in the vertical than in the horizontal meridian, and might be compared, in a rough way, to the convex surface of a spoon, when that is held horizontally. This variation from the typical form can be shown by a number of simple experiments.

If, for example, a circular pin-hole be made in a card, and held at varying distances from the eye, it will appear horizontally oval at one point and vertically or obliquely oval at another. The same principle can be illustrated in still another way. If upon a sheet of

paper a number of equally dark lines be drawn, radiating from a single point, like the spokes of a wheel, and this figure be held at a distance from the eye, it will be found that certain of these lines appear to be darker than others, although, in reality, they are all the same. It is unnecessary to multiply the experiments. The existence of this peculiarity has long been well known to oculists under the name of astigmatism. The great authority in the refraction and accommodation of the eye, Professor Donders, treats astigmatism as one of the qualities of the normal eye. The practical fact is, that we all possess this imperfection in a greater or less degree. When it passes beyond a certain point it then is classed as morbid, and requires suitable glasses to correct it. Now the point to which I wish to direct attention is, that when a person looks through the microscope at a series of fine parallel lines, it occurs very frequently that they cannot be seen on account of this peculiarity of his eye. At any rate, when one of Nobert's test-plates is subjected to examination, the perpendicular lines which one person would see perfectly well would not be seen by another person who might consider his vision in every way perfect. The same, of course, holds for other tests of a similar nature, such as diatoms of objects darked with fine dots or lines in close juxtaposition. This is by no means an imaginary difficulty, as it has been my experience more than once to find this difference of opinion between persons who are accustomed to view similar objects, and whose eyes and hands are trained to the use of the microscope. Fortunately, however, there is a very simple method of overcoming this difficulty. This consists in revolving the object on the stage of the microscope in such a way that lines which at first were vertical, become afterwards horizontal, for when turned through an arc of one hundred and eighty degrees, they then pass through every meridian in which it would be possible to see them, provided the amplification and definition be sufficient to make them at all visible. This question of the relation of astigmatism to test objects for the microscope, seems to have been overlooked by most, if not all, writers on the subject. Upon examination, however, it would appear to be of considerable importance, and as such I venture to direct to it the attention of the Society.

THE UREDINEÆ OF ILLINOIS--A LIST OF THE SPECIES.

T. J. BURRILL, Ph. D., F. R. M. S., Champaign, Ill.

The list of species herewith presented embraces all those now known to occur in Illinois. There are, according to the determinations made, species as follows: *Uromyces*, twenty; *Puccinia*, forty-eight; *Phragmidium*, five; *Ravenelia*, one; *Gynosporangium*, one; *Cronartium*, one; *Melampsora*, four; *Coleosporium*, two; *Uredo*, one (isolated); *Cæoma*, two (isolated); *Æcidium*, forty-one (isolated); *Ræstelia*, two (isolated).

This is a total of one hundred and twenty-eight species, including the isolated forms described, of *Uredo*, *Cæoma*, *Æcidium* and *Ræstelia*. There are known in the *Uromycetes* the three fruit forms, or the complete number of alternate stages, of four species, the second and third forms for eleven species, the first and third forms for one species and the third form alone for four species. For the *Pucciniæ* there are the three forms of six, the second and third of twenty-five, the first and third of two and the third alone of fourteen species.

In the case of *Phragmidium* we have the three forms of one species, the second and third of three, and the third alone of one species.

The four species of *Melampsora* have each the second and third forms and the two species of *Coleosporium* have also for each the second and third forms.

The *Ræstelia* form for the single species of *Gymnosporangium* has not been positively identified, but there is considerable evidence that the *Ræstelia* on orchard apple-trees is an alternate form of *Gymnosporangium macropus* on *Juniperus Virginiana*. Wherever the latter occurs the apple-trees in the vicinity are uniformly infested with *Ræstelia*, and this last is never found in wide districts where the red cedar does not grow. The native crab-apple is

affected in every way similar to the cultivated apple. The *Ræstelia* on the former has been identified as *R. penicillata* (Sow.) Fr., by Professor Farlow, and that upon the orchard apple is certainly very similar, if not identical, yet the specimens studied seemed to be *R. lacerata* (Sow.) Fr., if indeed these two species can be morphologically separated. Possibly some other species of *Gymnosporangium* does occur in Illinois on *Juniperus*, and thus two *Ræsteliæ* can be accounted for, but careful search instituted for the purpose has revealed only *Gymnosporangium macropus.* This latter is common and the galls are familiarly known as cedar-balls.

It should be said, the only proof we have, so far as personal studies are concerned, of the genetic connection of any of the supposed alternate forms, is their occurrence together and their peculiarities of growth—no cultural studies having been made. In cases where the connection of forms has been demonstrated by others, there has been no hesitancy in accepting the conclusions, but mere guesses have not been followed without the accompanying evidence from observation. Whatever mistakes may have been made have some reasonable groundwork of excuse. There is left, however, an unsatisfactorily large list of isolated, incomplete forms: *Uredo*, one; *Cæoma*, two; *Æcidium*, forty-one, and *Ræstelia*, two. One of the latter may be *Gymnosporangium macropus*, as already indicated and more surprising things occur than that both the *Ræstelia* enumerated belong to this one species.

Besides the *Æcidia* given in the list, there are several forms on various Compositæ which have not been specifically identified. We have described seven of these forms under *Æ. compositarum*, without, however, attempting to assign them to named species.

The distinction adopted between the so-called genera *Uredo* and *Cæoma* may or may not receive the sanction of critics; there is certainly nothing positive in usage, neither do the original generic descriptions aid one in separating the genera. The uredo-forms having the spores on pedicles are here classed under *Uredo*, those in which the spores are produced in vertical chains are assigned to *Cæoma*. The former appear never to be accompanied by spermagonia, the latter usually are, so that besides the method of spore production a relation is indicated to *Æcidium*. It is, therefore,

possible that what we class as *Cæoma* belong to the first rather than to the second fruit form of the real species.

Among the *Cæomæ*, that commonly known as "orange rust" on blackberry and raspberry leaves is one of the most remarkable. It is more commonly known to botanists as *Uredo luminatum*, Schw., but whatever may be said of the generic term, the specific name *nitens* certainly has precedence. The spores are produced in vertical chains and spermagonia are present. We have, therefore, written *Cæoma nitens*, Schw. Aside from its destructive effects on important cultivated plants, it is so conspicuous from the abundant bright-colored spores, completely covering the lower surface of infested leaves, that it draws the attention of the most casual observer. Among agriculturists and horticulturists, no leaf fungus, except, perhaps, wheat rust, is so generally recognized and identified as something abnormal to the host-plant. Certainly no leaf-parasite is better known by American mycologists. Yet we are in ignorance of its life-history, the final or perfect fruit-form is only guessed at. It is certain such an alternate spore-form does exist as an essential annual stage in the growth of the fungus, but here the certainty ends. Botanists have surmised it is the uredo-form of some *Phragmidium*. I venture to suggest, instead of the latter, *Puccinia Peckiana*, Howe, but the proof for a confident statement is not yet complete.

The group of species herein recognized as the genus *Melampsora* has not been distributed among the so-called allied genera. The distinctions do not seem to be necessarily generic ones, and the difficulty of making out the microscopical characteristics upon which these distinctions depend, at least, in dried specimens, practically precludes the generic separation.

The proposed genera, *Pileolaria*, *Uropyxis* and *Dicæoma*, have not been accepted; the first is included with *Uromyces* and the two latter with *Puccinia*.

There are numerous questions of identification and nomenclature which cannot be entered upon here. The effort has been made to reduce rather than multiply species, but much care has been taken in a conservative kind of way to ascertain what are entitled to specific distinction without much reference to the names

commonly employed. In every case the name having priority has been chosen, however this may conflict with more common usage. But in the question of priority, the æcidial name has not been considered. There is far too much uncertainty, in the absence of recognizable type specimens, of the intended application of the older æcidial names, and, especially, there is much too little real knowledge of genetic relationships to permit the adoption of æcidial names for teleutoform species.

The uredo, however, is more easily recognizable from published descriptions, and this form is found on the same host plant, often characteristically associated, in place and time, with the teleutoform. The objections to the adoption of the æcidial names do not equally apply to those of the uredo. In the present list the oldest, the earliest, name known for the uredo or teleutoform is the one chosen:

LIST OF SPECIES.

UROMYCES, LINK.

U. hyperici (Schw.), Curt..............	Hypericum mutilum. Elodea Virginica.
U. terebinthi (DC.), Wint..............	Rhus toxicodendron.
U. hedysari-paniculati (Schw.), Farlow..	Desmodium paniculatum. D. cuspidatum. D. Canadense. D. rotundifolium.
U. lespedezæ (Schw.), Peck............	Lespedeza procumbens. L. repens. L. violacea. L. hirta. L. capitata.
U. fabæ (Pers.), DBy..................	Lathyrus palustris. L. venosus. L. ochroleucus.
U. appendiculata (Pers.), Lev..........	Phaseolus vulgaris. P. diversifolius. P. helvolus.
U. œnotheræ, Burrill..................	Œnothera linifolia.
U. spermacoces (Schw.), Curt	Diodia teres.
U. rudbeckiæ, Arth. and Hol...	Rudbeckia laciniata.
U. Howei, Peck......................	Asclepias Cornuti.
U. polygoni (Pers), Fkl................	Polygonum aviculare, var. erectum. P. ramosissimum.
U. euphorbiæ, C. & P.................	Euphorbia maculata. E. hypericifolia. E. dentata. E. heterophylla.
U. caladii (Schw.), Farlow.............	Arisæma triphyllum. A. dracontium. Peltandra Virginica.
U. pyriformis, Cke....................	Acorus calamus.
U. sparganii, C. & P..................	Sparganium eurycarpum.
U. erythronii (DC.),...........	Allium striatum.
U. junci (Schw.), Tul..................	Juncus tenuis.
U. scirpi, Burrill.....................	Scirpus fluviatilis.
U. acuminata, Arthur.................	Spartina cynosuroides.

U. graminicola, Burrill	Panicum virgatum.
	Elymus Virginicus.

PUCCINIA PERS.

P. anemones-Virginianæ, Schw	Anemone cylindrica.
	A. Virginiana.
P. ranunculi, Seymour	Ranunculus repens.
P. podophylli, Schw	Podophyllum peltatum.
P. violæ, DC	Viola cucullata.
	V. striata.
	V. pubescens.
P. Mariæ-Wilsoni, Clin	Clatonia Virginica.
P. heterospora, B. & C.	Sida spinosa.
P. nolitangeris, Cda	Impatiens fulva.
	I. pallida.
P. amorphæ, Curt	Amorpha fruticosa.
	A. canescens.
P. pruni-spinosæ, Pers	Prunus Americana.
	P. Virginica.
	P. serotina.
P. Peckiana, Howe	Rubus villosus.
P. tiarellæ, B. & C.	Mitella diphylla.
P. proserpinacæ, Farlow	Proserpinaca palustris.
P. circææ, Pers.	Circæa Lutetiana.
	C. alpina.
P. pimpinellæ (Strauss), Lk	Osmorhiza longistylis.
	O. brevistylis.
P. galiorum, Lk	Galium concinnum.
	G. triflorum.
P. tenuis, Burrill	Eupatorium ageratoides.
P. kuhniæ, Schw	Kuhnia eupatorioides.
P. conoclinii, Seymour	Conoclinium cœlestinum.
P. asteris, Duby	Aster Shortii.
	A. sagittifolius.
	A. miser.
	A. Novæ-Angliæ, etc.
P. silphii, Schw	Silphium terebinthinaceum.
	S. integrifolium.
	S. perfoliatum.
P. xanthii, Schw	Ambrosia trifida.
	Xanthium strumarium.
P. tanaceti, DC	Helianthus annuus.
	H. rigidus.
	H. mollis.
	H. decapetalus, etc.
P. tanaceti, DC., var. vernoniæ, Burrill.	Vernonia fasciculata.
P. flosculosorum (Alb. & Schw.), Rœhl.	Cirsium discolor.
	C. lanceolatum.
	Taraxacum dens-leonis.
	Hieracium Canadense.

P. maculosa, Schw	Cynthia Virginica.
P. lobeliæ, Gerard	Lobelia syphilitica.
	L. perberula.
P. seymeriæ, Burrill	Seymeria macrophylla.
P. lateripes, B. & R	Ruellia ciliosa.
	R. strepens.
P. menthæ, Pers	Mentha Canadensis, etc.
	Cunila Mariana.
	Pycnanthemum pilosum.
	P. lanceolatum.
	P. linifolium.
	Monarda fistulosa.
	M. Bradburiana.
	M. punctata.
	Blephilia hirsuta.
P. glechomatis, DC	Lophanthus nepetoides.
P. plumbaria, Peck	Phlox divaricata.
P. convolvuli, Cast	Calystegia sepium.
P. gentianæ (Strauss), Lk	Gentiana puberula.
P. polygoni-amphibii, Pers	Polygonum amphibium.
	P. Virginianum.
	P. acre (Uredo only).
	P. Pennsylvanicum (Uredo only).
P. aletridis, B. & C	Aletris farinosa.
P. smilacis, Schw	Smilax hispida.
P. caricis (Schum.), Rebent	Carex (species).
	Dulichium spathaceum.
P. obtecta, Peck	Scirpus validus.
P. angustata, Peck	Scirpus atrovirens.
P. windsoriæ, Schw	Muhlenbergia (species).
P. graminis, Pers	Triticum vulgare.
	Avena sativa.
	Agrostis vulgaris.
	Hordeum jubatum.
P. phragmitis (Schum.), Krnck	Spartina cynosuroides.
	Phragmites communis.
	Andropogon furcatus.
	A. scoparius.
P. rubigo-vera (DC.), Wint	Triticum vulgare.
	Avena sativa.
	Secale cereale.
	Elymus Virginicus.
P. coronata, Corda.	Avena sativa.
	Triticum vulgare.
P. emaculata, Schw	Tricuspis seslerioides.
	Eragrostis pectinacea.
	Panicum capillare.
	P. virgatum.
P. flaccida, B. & Br	Panicum crus-galli.
P. andropogi, Schw	Andropogon furcatus.
	A. scoparius.
P. maydis, Carradori	Zea Mays.

PHRAGMIDIUM, LINK.

Ph. fragariæ (DC.), Rossm	Potentilla Canadensis.
Ph. mucronatum (Pers.), Lk	Rosa———.
Ph. speciosum, Fries	Rosa———.
Ph. rubi-idæi (Pers.), Wint	Rubus strigosus.
Ph. rubi (Pers.), Wint	Rubus villosus.

RAVENELIA, BERK.

R. glaudulæformis, B. & C	Tephrosia Virginiana.

GYMNOSPORANGIUM, DC.

G. macropus, Lk	Juniperus Virginiana.

CRONARTIUM, FRIES.

C. asclepiadeum, Kze. Var. thesii, Berk	Comandra umbellata.

MELAMPSORA, CAST.

M. epilobii (Pers.), Fkl	Epilobium coloratum.
M. Crotonis, Burrill	Croton capitatum. C. monanthogynum. Crotonopsis linearis.
M. salicina, Lev	Salix cordata. S. longifolia, etc.
M. populina, Lev	Populus tremuloides. P. monilifera.

COLEOSPORIUM, LEV.

C. sonchi-arvensis (Pers.), Lev	Vernonia fasciculata. Elephantopus Carolinianus. Aster sagittifolius, etc. Solidago latifolia. S. altissima. S. ulmifolia. S. Canadensis. S. gigantea, etc. Silphium integrifolium. S. terebinthinaceum. Helianthus (species).
C. ipomϾ (Schw.)	Ipomœa Nil. I. lacunosa. I. pandurata.

UREDO, LEV.

U. hydrangeæ, B. & C	Hydrangea arborescens.

CÆOMA, TUL.

C. agrimoniæ, Schw	Agrimonia Eupatoria. A. parviflora.
C. nitens, Schw	Rubus occidentalis. R. villosus.

ÆCIDIUM, PERS.

Æ. ranunculacearum, DC.	Anemone Pennsylvanica.
Æ. ranunculi, Schw.	Ranunculus abortivus.
Æ. punctatum, Pers.	Hepatica triloba. Anemone nemorosa.
Æ. actææ (Opiz.), Wallr.	Actæa spicata.
Æ. dicentræ, Trelease.	Dicentra cucullaria.
Æ. Mariæ-Wilsoni, Peck.	Viola cucullata.
Æ. hibisciatum, Schw.	Hibiscus militaris.
Æ. geranii, DC.	Geranium maculatum.
Æ. impatientis, Schw.	Impatiens.
Æ. pteleæ B. & C.	Ptelea trifoliata.
Æ. onobrichidis, Burrill.	Psoralea Onobrychis.
Æ. psoraleæ, Peck.	P. floribunda.
Æ. leucostictum, B. & C.	Lespedeza procumbens.
Æ. orobi, Pers.	Amphicarpæa monoica.
Æ. grossulariæ, DC.	Ribes rotundifolium. Cultivated gooseberry.
Æ. epilobii, DC.	Œnothera biennis.
Æ. œnotheræ, Peck.	Œnothera biennis.
Æ. sambuci, Schw.	Sambucus Canadensis.
Æ. diodiæ, Burrill.	Diodia teres.
Æ. cephalanthi, Seymour.	Cephalanthus occidentalis.
Æ. houstoniatum, Schw.	Houstonia cœrulea.
Æ. erigeronatum, Schw.	Erigeron Canadense. E. bellidifolium. E. Philadelphicum. E. annuum.
Æ. asterum, Schw.	Aster sagittifolius, etc. Solidago latifolia. S. cæsia. S. rigida. S. altissima, etc.
Æ. compositarum.	Compositæ.
Æ. plantaginis, Ces.	Plantago Virginica.
Æ. lysimachiæ (Schl.), Wallr.	Lysimachia ciliata.
Æ. pentsemonis, Schw.	Pentsemon pubescens.
Æ. lycopi, Gerard.	Lycopus Europæus.
Æ. myosotidis, Burrill.	Myosotis verna.
Æ. hydrophylli, Peck.	Hydrophyllum appendiculatum.
Æ. polymonii, Peck.	Polymonium reptans. Phlox pilosa.
Æ. solani, Mont.	Physalis viscosa.
Æ. apocyni, Schw.	Apocynum cannabinum.
Æ. Jamesianum, Peck.	Asclepias Cornuti.
Æ. fraxini, Schw.	Fraxinus viridis.

Æ. pustulatum, Curtis................Comandra umbellata.
Æ. euphorbiæ, Gmel...................Euphorbia polygonifolia.
E. hypericifolia.
E. maculata.
E. dentata.
Æ. crotonopsidis, Burrill..............Crotonopsis linearis.
Æ. urticæ, Schum....................Urtica.
Æ. smilacis, Schw....................Smilax herbacea.
Æ. trillii, Burrill....................Trillium recurvatum.
Æ. convallariæ, Schum...............Smilacina racemosa.
S. stellata.

RŒSTELIA, REBENT.

R. lacerata (Sow.), Fr.................Cratægus tomentosa.
C. coccinea.
R. penicillata (Sow.), Fr..............Pyrus coronaria.

A HELIOSTAT FOR PHOTO-MICROGRAPHY.

By S. W. STRATTON and T. J. BURRILL, Champaign, Ill.

Having had occasion to use a heliostat, and not caring to incur the expense of purchasing one at the usual price, it occurred to me that an instrument possessing the essential qualities of the finer instruments, but much cheaper and simpler, would answer quite well enough for photo-micrography by sunlight. No doubt many besides myself have heretofore been prevented from giving the heliostat a fair trial in this kind of work, because of inability to procure one at a reasonable price. This being the case, it was determined to design an instrument, that while being moderately cheap, should be simple and so adjustable as to eliminate as many of the errors of construction as possible, quickly put in operation, easily kept in order, and requiring but little attention after once being properly set and regulated. The following expresses in as few words as possible, both the mathematical and mechanical solutions of the problem:

Let OA (*fig. 1*) be an axis parallel to that of the earth, and turned by suitable mechanism at the rate of one revolution in twenty-four hours. BC is a pointer attached to OA so that it takes the motion of OA: then if the angle BOA is made equal to $90° +$ or — the sun's declination, according as it is north or south, BC will revolve in the plane of the sun's apparent motion; and if BC is set to point at the sun, it will follow the sun, remaining approximately parallel to the sun's rays throughout the day. DE is a mirror hung on an universal joint, permitting it to take any position whatever about the point I. IC is a perpendicular to the mirror at I, and is attached to the pointer at C, so that the length of IC may vary. OC is made equal to the distance OI and remains so. OIC is, therefore,

an isosceles triangle, OIC and OCI being its equal angles. Let $B'I$ parallel to BC be an incident ray and LI the extension of the perpendicular to the mirror; then the angle of incidence $B'IL$ = angle OCI. The angle of incidence is equal to angle of reflection; let LIL' be the angle of reflection = angle LIB' = angle OCI = angle OIC by construction; therefore, $L'I$ and IO are one and the same

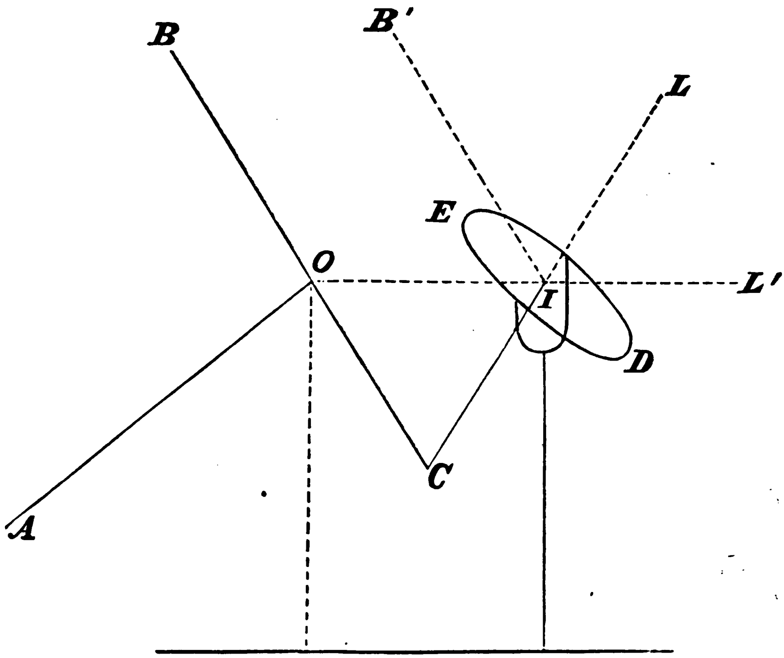


Fig. 1.

straight line, hence the reflected rays are parallel to IO, and it is easily seen that as long as the point I remains at a constant distance from $O = OC$, the ray $B'I$ will be reflected in the line $L'I$, and by changing the direction of OI we may reflect the rays in any desired direction.

Its construction is shown in *fig. 2*. Here $m\ n$ is an arc graduated to degrees: its center is at O. The block A slides upon the arc and is fastened in any position by the set-screw a. The block carries the clock and the axis OA; OA coinciding with the radius

of the arc. Then if the plane of the arc be made to coincide with the plane of the meridian through the place, the instrument leveled, and the angle of *OA* with the horizontal be made equal to the latitude of the place, *OA* will be parallel to the earth's axis. The pointer *BC* has a movement about *O* in the plane of *OA* and *BC*, of $23\frac{1}{2}^\circ$ either side of its position perpendicular to *OA*, and is clamped in any desired position by the screw at *O*. The pointer, *BC*, is

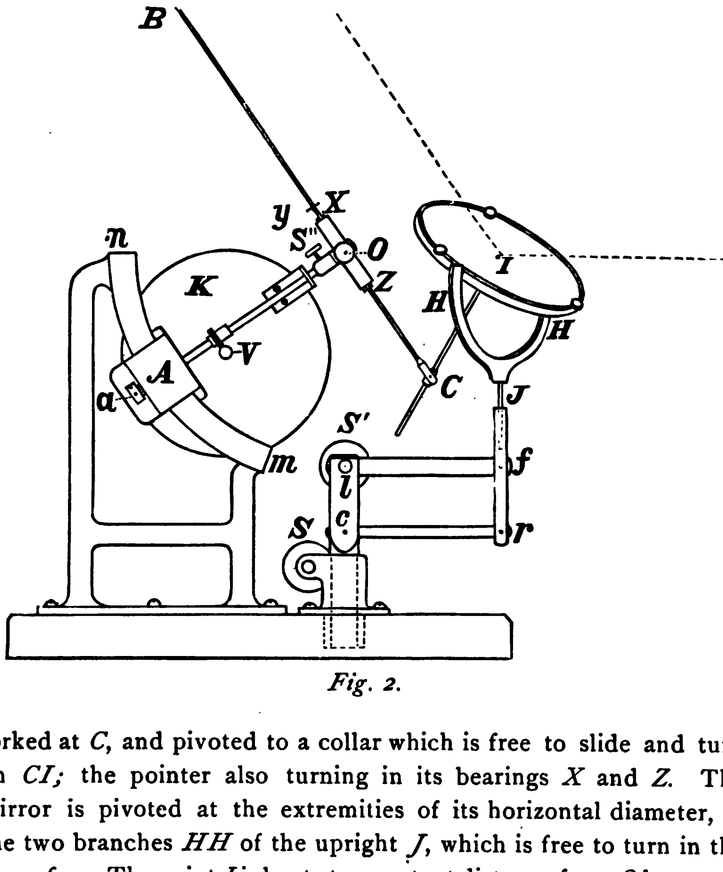


Fig. 2.

forked at *C*, and pivoted to a collar which is free to slide and turn on *CI*; the pointer also turning in its bearings *X* and *Z*. The mirror is pivoted at the extremities of its horizontal diameter, to the two branches *HH* of the upright *J*, which is free to turn in the piece *f r*. The point *I* is kept at a constant distance from *O* by means of the parallelogram of *f r c l*. The sides *f l* and *r c* are equal to *IO*; *f r* is extended above to receive the upright *J*, and *l c* below to serve as a vertical axis. The center of the axis, the pivots *c* and *l*

and that of motion at *O* (which coincides with the center of the arc) are in the same vertical lines, *c l* being slotted above the bearing to receive the two long sides of the parallelogram. By revolving the parallelogram about the vertical axis *l c*, we may change the direction of *OI* and hence the reflected ray in azimuth, the axis being clamped in position by the thumb-screw *S*. By racking the parallelogram about its joints, the attitude of *OI* is made to vary and kept in position by the thumb-screw S′; therefore *I* describes arcs of circles about *O* as a center.

This arrangement for changing the direction of the reflected ray quickly, is very convenient when using oblique light and to throw the light upon the exact spot where needed; it serves, also, if the instrument is not in adjustment, to correct the deviations of the ray, with but little trouble. The revolution of the axis *OA* may be accomplished with any good spring clock-works, the hands and mechanism of the hour-hand being removed and the works placed in a case specially provided for them. This case is carried by the block *A*, the minute-hand arbor being at right angles to *OA*; that is to say, perpendicular to the plane of the arc *m n*. On the arbor is placed an endless screw *V*, which engages a wheel on *OA* having twenty-four teeth. Twenty-four revolutions of the screw will then cause one revolution of *OA*, and as the arbor makes one revolution per hour, we have the desired daily rotation of *OA*.

The whole is secured to a hardwood base provided with three leveling screws and a level (not shown in the figure). The various parts may be constructed of whatever material appears best for each, cast and rolled brass being probably the best for the main pieces, and Stub's polished steel wire for the axes, screws, pivots, etc.

To put the heliostat in operation after having placed it in the meridian and leveled it, the set-screws *S″* and *O* are loosened and the pointer is made to point directly at the sun by turning it about *OA* and *O* until the shadow of *BC* is not seen on the small disk *y*; set the screws *S″* and *O*, and the pointer is carried around by *OA* in its daily revolution. The shadow not only serves to get the sun's declination and altitude without graduated arcs, but gives us a means of regulating the clock. If the instrument is started and after some time has elapsed the shadow of *CB* is seen on the disk *y*,

we infer that the pointer is gaining or losing on the sun, according as the shadow is on the advance or rear side of pointer; and the clock may be regulated to correspond.

NOTES.—The movement is not exact, for the following reasons:

1.—The pointer is keeping mean solar time, which is gaining or losing on true solar time.

2.—The sun is, apparently, going north or south from the equinoxes; hence, if the pointer is set at any moment with the correct declination, at a later time the sun will have varied in declination, while that of the pointer remains constant.

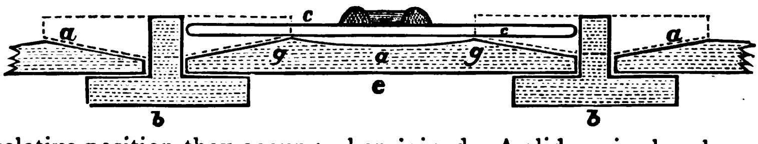
But as the instrument is in use for only from 6 to 8 hours out of the 24, these errors are very much smaller than the errors of construction, and are practically zero.

IMPROVED METHOD OF CONSTRUCTING SLIDE CABINETS.

By Henry E. Summers, Ithaca, N. Y.

It was my aim, in making the cabinet to be described, to combine the advantages of the different existing cabinets known to me, and at the same time to so simplify the construction that it could be made cheaply and by an ordinary carpenter with the tools usually at his command. The advantages spoken of, all of which should be found in any cabinet approaching perfection, are: (1.) Each slide should have a separate compartment. (2.) The slides should be easily removable. (3.) They should not rest upon the support immediately beneath the object. (4.) They should lie flat while the cabinet is in its ordinary position. (5.) They should be so held that the object cannot be injured if the cabinet is overturned in transportation.

The cabinet constructed was intended for slides of the ordinary length, three inches; but of two widths,—one inch, and two inches. The drawers are made up of strips or moldings of two forms. These are shown in section in the diagram, drawn to scale, in the



relative position they occupy when joined. A slide, *c*, is also shown in place. The strips *a a* and *b b* run from the front to the back of the drawer. The slide *c* rests on the two ridges *g g* of the strip *a*. Between the ridges *g g*, the strip *a* is slightly hollowed, to prevent contact of the slide beneath the object, and consequent soiling. From the ridges *g g* to the edges, the strip *a* is beveled, so that one end of the slide may be tipped up by pressure upon the opposite end, in order that it may be grasped more readily. The strips *a a*

rest in rebates in the strips *b b*. These rebates are of such a depth that when the strips *a a* are in place the upper surface of one of the thickest slides in use will be just a trifle lower than the top of the strips *b b*. The cover glass or cell upon the slide may project above the top of the strips *b b*. The object will then extend up into the space *e* of the drawer above. This space should hence be high enough to admit the deepest cells.

The partitions between the sides of adjacent slides are merely short, thin strips of wood, tin, or better, ferrotype plate, set at proper intervals in grooves sawed across the upper part of the strips *b b*. If desired, these portions may be continuous across the drawer, but the short strips seem to serve every purpose, and are more easily inserted. If a cabinet has been entirely divided up for slides one inch wide, and it is desired to insert one two inches wide, a portion can be removed without in any way disturbing the rest of the drawer.

When these drawers are inserted in a cabinet, the strips *b b* are allowed to slide upon, or at least approach very near to, the corresponding strips of the drawer below. In case of overturning, the slides are held in place by the side projections of the strips *b b* of the drawer above. The two outer strips, *b b*, of each drawer form the sides of that drawer, the side projections of the strips in this case sliding in grooves in the sides of the cabinet, thus supporting the drawer. In the front and back of the drawer, it should be observed that the part opposite the space *e* must belong to the drawer *below*, in order that deep cells may not be injured when the drawers are slid in or out. The irregularity thus produced may be rendered inconspicuous by placing over these portions the porcelain tablets usually used for the members of the drawers and of the contained slides.

I would call attention to the fact that the two forms of strips used in this cabinet may be planed out in length by machine if a large quantity is to be used, and then cut up for drawers of any desired depth. As many as desired may be joined side by side to form drawers of any width.

A NEW FORM OF LIFE-SLIDE.

By JAMES H. LOGAN, Pittsburgh, Pa.

In the examination of living forms many have doubtless experienced difficulty in preserving fine specimens alive for prolonged observation. After resorting to various expedients, the writer was led to devise the life-slide herein described, and although it may not be altogether perfect, it appears to afford so many advantages that it is worthy of consideration.

The slide consists of a glass slip of the usual size, but $\frac{1}{4}$ inch thick. An annular channel as deep as the thickness of slide allows is ground out for an air-space, and outside of this a much narrower and quite shallow channel is cut. This last is for holding beeswax or wax and oil, to cement down the cover and prevent evaporation of inclosed fluid. A drop of water placed in center of slide and flattened down to a stratum as thin as the objects under examination will permit, is in a very favorable condition for examination. The Infusoria, thus confined, can move freely in every direction except the vertical, and are always in focus. The air channel also serves to hold any excess in the amount of fluid, above that required to fill the area of the circular field.

In this slide Infusoria may be isolated and sealed up, where they may be kept alive and in good condition for a week or more. In some temporary slides, where the air-space was much too small, there being no channel, the rotifers, amœbas and other forms, were alive and active for nearly a week.

Beeswax alone seems the best cement for sealing. If put in a syringe having a very small nozzle, and warmed, the wax may be forced out as a long, thin thread. This can be wound on a spool

and kept ready for use when a slide is to be sealed up. A piece long enough to fill the outer channel is placed therein. A glass slip placed over the cover glass, and, pressed down securely, seals the cell and, as the wax is soft, the stratum of fluid can be made as thin as desired.

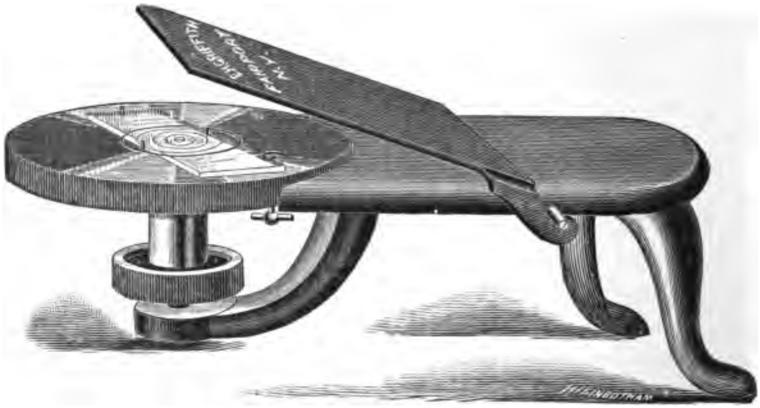
NOTE.—For picking out Infusoria, or rotifers, a common medicine-dropper with the point drawn out finer than usual seems to me to be the best thing so far devised. With a little practice, one can learn to pick these out under the microscope. For this purpose the microscope should stand vertically, and a plain slide containing a mass of fluid be placed on the stage. When an object is found, the observer draws it into the medicine-dropper and transfers to life-slide.

SOME NEW AND IMPROVED APPARATUS.

By E. H. Griffith, F. R. M. S., Fairport, N. Y.

GRIFFITH TURN-TABLE NO. 4, IMPROVED.

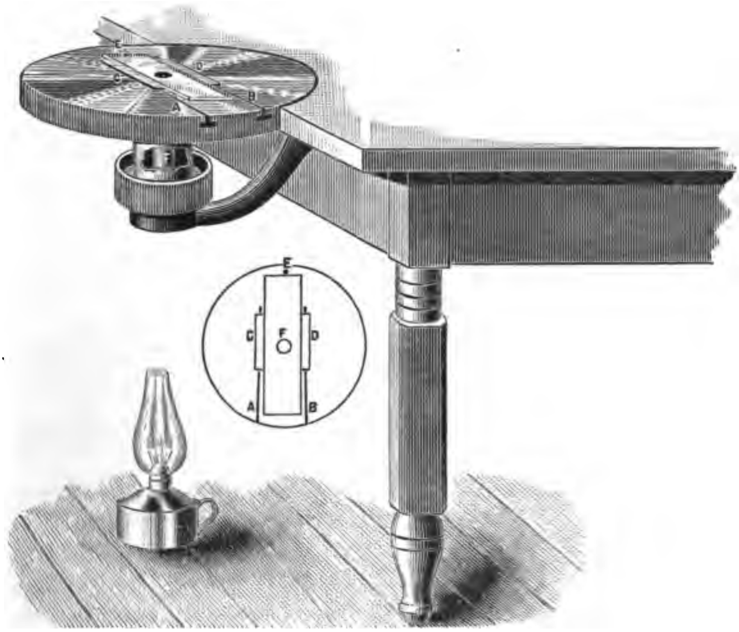
The center of the Table, marked with the circles, has a straight spring attached to it beneath. The slide being placed between the two pins in this center, is partially rotated against the spring and pushed forward, when the spring keys it between the two pins and a third fixed pin at the upper side of the slide, centering it perfectly



for width. The fourth pin at the left end, $1\frac{1}{2}$ inches from the center, is for length, and allows the slide to be always placed in the same relative position. The recent improvements add much to the value of the table. One of them is a countersunk decentering wheel and pin, which may be seen at the upper right-hand side of the slide. The axle of the wheel passes through the table and is furnished underneath with a short bar with which the decentering wheel may be turned, forcing the pin against the slide, pushing it as far out of center as may be desired. Another improvement is in making the end-pin a screw which may be turned down out of the way if desired.

GRIFFITH TURN-TABLE NO. 6.

This Table has two grooves, A and B, milled across the upper surface, equidistant from the center and tending towards a common point beyond. To these grooves are fitted two followers, and to the followers are fastened two thin, narrow brass plates, C and D, parallel to each other, and which are the slide-holders. The pin, E, is a small screw which may be turned back out of the way or used as an end-pin, it being $1\frac{1}{2}$ inches from the center of the table. The

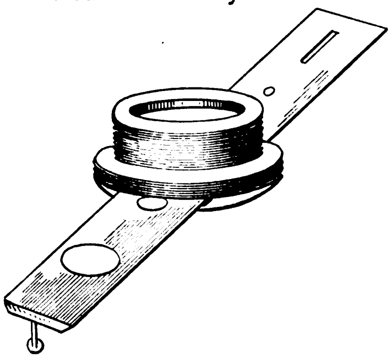


slide may be placed between the two plates, C and D, and made to abut against the end-pin, E. Then if C and D are pushed the same distance in the direction of E, they will clamp the slide firmly and center it perfectly for width. If it be desired to decenter the slide, one of the plates must be pushed farther than the other.

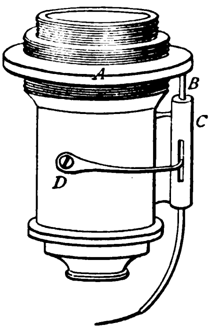
Some years ago General William Humphrey, of Jackson, Mich., an expert preparer of slides, suggested that an arrangement for illuminating the center of slides would be of great convenience, and the hollow spindle in this Turn-table is the result of the suggested need. A small mirror may be placed underneath and the light be reflected through the spindle, or a lamp may be used for the same purpose.

GRIFFITH SUB-STAGE DIAPHRAGM.

The Griffith Sub-Stage Diaphragm is intended as a substitute for the cheaper kind. The principal claims for it are that it will do the work well that is required of much more expensive ones, and as it is placed in the center of the sub-stage fitting, and so constructed that it may be turned in any direction, many effects may be secured by simply moving the slide. Being central it is not so much in the way as some other forms.



It is simply a perforated metal button fitting the society-screw of the sub-stage. Through the head is a groove, cut with a milling-machine, which is provided with a diaphragm slide which has different sized and shaped apertures which can be placed exactly central by means of stops, or out of center if desired. The slit can be made to be perpendicular, diagonal or longitudinal to the slide, as desired, by turning the button.



THE GRIFFITH MECHANICAL FINGER OBJECTIVE.

The collar, *A* (*fig.*), moves on a fine thread and forces down the bristle-holder, *B*. A slit in *C* keeps *B* in position. On turning *A* back, the spring, *D*, lifts the finger. The jacket to which *C* and *D* are attached turns on the objective. So that the object picked up, *e. g.*, a diatom, may be turned as desired. By lifting *D* the finger can be removed.

A COMBINED FOCUSSING AND SAFETY STAGE FOR USE IN MICROMETRY WITH HIGH POWERS.

By C. M. Vorce, F. R. M. S., Cleveland, O.

This device consists of two perforated brass plates, the upper bearing two spring clips to hold the slide, and the lower having springs lifting the upper plate and also a micrometer screw at each end passing up freely through the upper plate, which is depressed by milled nuts on the micrometer screws, opposed by the lifting-springs of the lower plate. All this is shown in the sectional view of the focussing stage (*fig. 1*), and needs no further description, as

Fig. 1.

the action of the parts is obvious. The object of the device is to move the slide instead of the objective in focussing, in order that when making measurements by projecting the image on a screen the distance of the screen from the focal point of the objective may remain absolutely unchanged, which is necessary to avoid the objection that the power has been changed by changing this distance. In micrometry it is essential to avoid, so far as possible, every theoretical as well as every practical source of error, even if it should be too minute to affect, appreciably, the result. And especially is this true of micrometry applied to determine, judicially, important questions. In micrometry there are, with all the ordinary appliances, some theoretical sources of error, which, although in most cases so minute as to be, in their effect upon the accuracy of the result, practically *nil*, are sufficient to afford pretexts for objection on the part of those who

seek to magnify every defect to be found in the work of others whose results are not agreeable to the views or wishes of those who so object. The identity of results by different methods, and correlation of tests, may often show a given method to be practically exact, yet, if any theoretical objection can be raised against it, it may often be so treated as to completely discredit results that are in point of fact accurate and reliable, and, unfortunately, the less scrupulous the party who thus seeks to discredit such results, the greater the success likely to attend his efforts.

Therefore, it is a matter of some importance that any microscopist who may be called upon to make micrometic measurements to determine any given point should adopt such methods as are the least open to objection on account of inherent theoretical errors, for it is obviously important that his work, if correct, shall stand as authoritative and not be discarded, and there is, as experience has shown, much less danger that erroneous work will be accepted as authoritative than that really correct work will be laid open to doubt. This is well illustrated by the case of the stage micrometer. Every microscopist knows that if any one should succeed in ruling a micrometer *absolutely exact and correct*, one in which the spaces were all exactly equal and of exactly the value designed, yet it would be months and probably years before its accuracy would cease to be doubted and disputed, and every possible point which theory could raise involved in its production, and by any possibility susceptible of causing error in the result, would be urged against its reliability. In forensic micrometry, by which term I mean all cases in which micrometry is applied to afford evidence of some fact involved in the judicial determination of a question by the courts, it is especially important that no unnecessary chance should be afforded any one to cast doubt upon the accuracy of the methods employed or upon the validity of the result obtained. At the best, enough will be done by one side or the other to raise suspicion and doubt as to the reliability of the micrometry, even with the narrowest ground to work upon.

The foregoing, with other considerations, induced me to adopt the following method of micrometry for high powers: Instead of using extremely high-power objectives to gain great magnification,

tube length, as advocated by Beale, is employed, and the image is viewed direct, *i. e.*, without magnification by eye-piece, the method having been suggested in part by former experience in the micrometry of blood, and in part by experience in photo-micrography. A base-board is provided, some four or five feet long, at one end of which the lamp is placed enclosed in a light-tight box. A magic lantern answers admirably for illumination, connecting its condenser tube with the stage of the microscope by means of a light-tight sleeve. The microscope is placed horizontally with amplifier in place and tube as short as possible and internally blackened to avoid reflection. A movable vertical screen, faced with white card-board or glass, is adjusted on the base-board at such distance from the microscope as is found suitable, but need not, ordinarily, exceed two feet, and is clamped in place when adjusted. The focussing stage is adjusted on the microscope stage, clamped in place, and a micrometer is put in place and focussed, the image being observed on the screen. When the desired power is gained by moving the screen along the base-board it is clamped in place and the lines of the micrometer, as seen on the screen, are traced by means of a ruler and pen on the face of the screen, and by the use of dividers the spaces may be further subdivided. In the measurements to be made the microscope and screen are not moved in the least, nor even touched, except to turn the screws of the mechanical stage. The micrometer is removed by pressing down the top plate of the focussing stage, the slide containing the objects to be measured is substituted and the plate, on being released, brings the slide into focus, if it is of the same thickness as the micrometer, if not, it is brought into focus by the focussing screws of the focussing stage. When focussed, the image on the screen is viewed and the measurement read off and noted as the slide is passed along by the movement of the mechanical stage. If, owing to uneven thickness or curvature of the slide or cover, the object begins to pass out of focus, it is focussed by means of the screws of the focussing stage. The operator sits, ordinarily, near the screen, working the stage with the left hand and noting the measurements with the right: the milled nuts of the focussing stage are easily reached, and the work proceeds rapidly; although two operators, one to note down the

measurements as called off by the other, and occasionally changing places, facilitate the work. The arrangement of apparatus is shown in *fig. 2*.

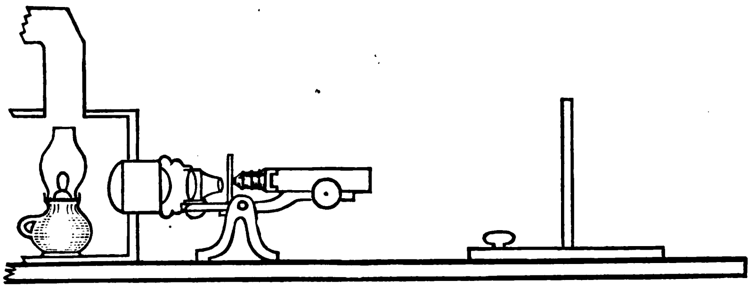


Fig. 2.

It is obvious that with this device the power employed is always the same, when once adjusted, and enlargement up to 5,000 diameters may be obtained. The micrometer eye-piece, where the body is moved by the fine adjustment, is also practically unchanging in power, but cannot easily afford the same amount of magnification, unless with unusually high-power objectives whose short working distance usually precludes their use with tube lengths sufficient to give so great amplification.

A very convenient method of using the focussing stage in micrometry is to so adjust the screen that .001 inch of the stage micrometer exactly equals 1 inch of the paper scales used by architects and divided into hundredths of inches; by pasting one of these scales across the screen and bringing the micrometer lines (of .001 inch) to coincide with the inch lines of the scales, as shown in *fig. 3*, and clamping the screen in that position, a scale upon the screen is obtained reading to $\frac{1}{100000}$ inch, which is far finer than can ordinarily be utilized, although by sunlight the striæ of some diatoms, such as *F. saxonica* and *A. pellucida*, will puzzle the eyesight in attempting to count their striation by means of the scale.

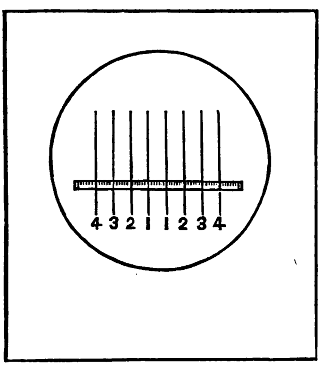


Fig. 3.

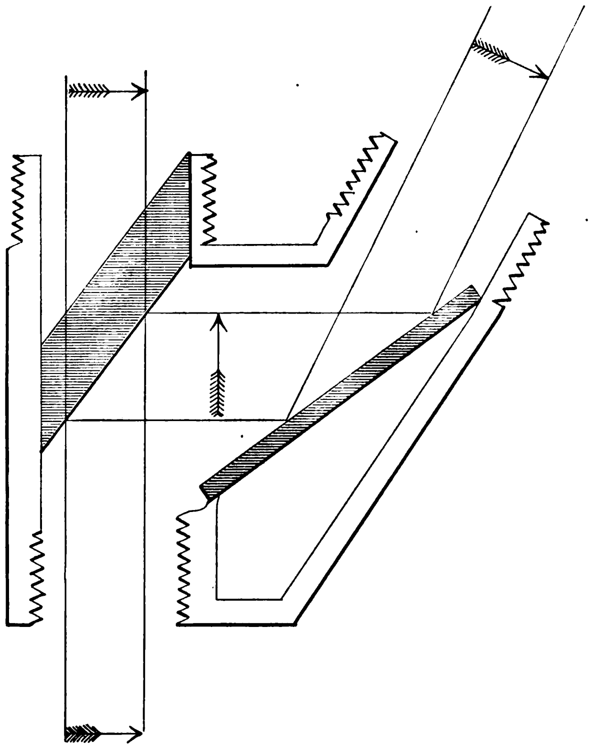
An incidental feature of this focussing stage is that it will not allow the slide or cover to be broken in focussing, and is, therefore, a safety stage as well.

In making measurements by this method the same spaces of the scale should be used for every measurement, and, preferably, the central ones, thus removing any question as to variation of power or aberrations in the extreme edges of the field. Thus, if the objects measured are about 1½ or 2 divisions of the scale, and two are in the field at once, do not read the dimensions and record them as they stand, but bring first one of the objects to the central line and read from that, and note the measurement; then bring the other object to the *same side* of the central line, read and record as before: both are then measured by the same part of the scale to the extent of the smaller.

REMARKS ON A DEVICE FOR ENABLING TWO OBSERVERS TO VIEW OBJECTS SIMULTANEOUSLY.

By JAMES H. LOGAN, Pittsburg, Pa.

Microscopists are generally familiar with the arrangement of rachet by which two or more persons can examine an object under the microscope at the same time. It occurred to me that an ap-



paratus for this purpose would be more convenient and useful if arranged in a box so that it could be applied to any microscope and readily removed when not wanted.

[The device was presented for inspection. The accompanying figure will doubtless make clear its construction, without specific description.]

Half of the rays from the object proceed directly up the main tube, and the other half are reflected into the other one. The reflected rays, however, do not cross those of the main tube, but are reflected outside; otherwise the arrangement resembles that of the Wenham binocular prism.

Either such a modified Wenham prism may be used, or two plain reflectors.

The one submitted for examination is an experimental one, and works fairly well. Experiments are still being made, the endeavor being to perfect an apparatus that will utilize the whole aperture of the objective in each tube, instead of half, as in the present arrangement.

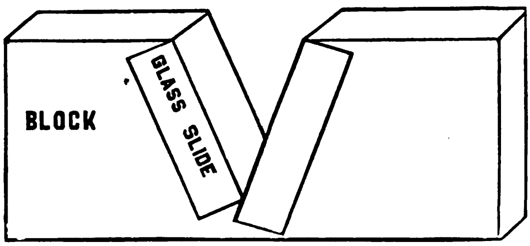
RAPID SECTION CUTTING.

By JAMES E. WHITNEY, F. R. M. S., Rochester, N. Y.

For the benefit of those who have so little time for microscopic work that every minute is precious, we will describe a single contrivance for section cutting which is nearly as rapid as free-hand cutting, and yet enables one to make really good sections with more certainty.

Where one wishes to make sections of numerous vegetable tissues for comparative study, and has only a short time for the purpose, the tedious process of imbedding necessary with ordinary machines is a serious obstacle.

To avoid the necessity of imbedding the object at all, we simply cut in a block of hard wood (say 3 inches by 4, and $1\frac{1}{2}$ inches thick), a wedge-shaped opening, $1\frac{1}{4}$ by 2 inches, or thereabouts, into which the object to



be cut is placed so that its sides touch the tapering sides of the opening and prevent motion. On the top of the block over which the blade of the razor is to pass, we cement two pieces of glass slides with their smooth edges parallel with the edges of the wedge-shaped cut.

For the ordinary rapid examination of vegetable tissues, the specimen is held gently in the opening by the thumb of the left hand, while the razor dipped in alcohol is drawn steadily over the glass slips toward the apex of the wedge, with the cutting edge held at the usual angle. After the first cut, if uniformity in the thinness

of the sections is not necessary, the object can be simply advanced slightly by the hand, and after a few trials it will be found that really thin sections can be easily made in this simple way.

When, however, it is necessary to have sections of extreme or uniform thinness, it is best to screw across the under side of the block a strip through which a thumb-screw with fine thread is fitted to work. By this means the object can be raised regularly any desired distance at each cutting.

The block can be prepared in a few minutes by any one, and with all ordinary vegetable tissues, very satisfactory sections can be cut. Hard wood cannot be cut safely in a section cutter without being first soaked or steamed, and as a keen-edged plane will cut beautiful sections quickly and easily, it is best to cut such wood in that way. Sections of different kinds of wood can be cut at the same time by screwing small blocks of each together and taking a section of all at one stroke of the plane.

REMARKS ON IMPROVED METHODS.

By R. N. Reynolds, Detroit, Mich.

I. *To transmit Sections by Mail.*

Having occasion frequently to send sections of various kinds by mail, I have devised and successfully used the following plan by which the objects are kept saturated with alcohol without infringing the postal law forbidding the mailing of liquids: In a wide-mouthed half-ounce bottle a little alcohol is placed, sufficient to saturate the papers used in packing the sections. Some two inch squares of tissue paper are then cut, on which the name of the section is written with a lead pencil; on this the section is placed and the paper folded over it, care being taken not to fold the section; the parcel is then dropped into the bottle, resting flat on the bottom. Repeat this with as many sections as desired, or until the bottle is filled. In case the parcels do not fill the bottle, complete it by a wad of tissue paper. The bottle may then be mailed as usual by boring a hole in a block of wood and packing with paper. The sections are, of course, removed on reaching their destination by unfolding the parcels in alcohol and floating off the specimens.

In case of very delicate sections it is well to float them into paraffined paper or writing paper; straighten out the folds of the section by holding the folded portion in alcohol and manipulating it with a small red-sable brush; then cut away the uncovered portions of the paper and then pack as before.

II. *To mark Desirable Parts of Mounts without Maltwood Finder or Special Diamond.*

The object is brought into focus of a suitable objective, and a strip of gummed paper about an inch and one-half long, with a pin-hole near its center, is passed under the objective so that the desired object is seen through the perforation; when this is done

one end of the paper is moistened and pressed down firmly to the slide while the other is held in position, after which it is also moistened and pressed to place. The slide is next put upon the turn-table and the pin-hole brought approximately to center; a small circle made with a pencil will show what adjustment is necessary to exactly center the hole and consequently the special object; successive circles and adjustments finally accomplish this; then carefully cut away the paper and make a very small circle on the cover glass with a writing diamond or with a very small pointed brush dipped in thin, colored cement.

III. *To safely handle Fresh Balsam Mounts.*

It is sometimes desirable to handle or transport fresh balsam mounts; this can usually be done without injury by the use of two pieces of thin gummed paper, about three-eighths of an inch square, applied to the slide in opposite sides of the cover glass, allowing each paper to reach about a sixteenth of an inch upon the cover. When it is desired to dress up the mount, the papers are removed by a few minutes soaking in water.

I. NOTES ON THE EPITHELIUM LINING THE MOUTH OF NECTURUS AND MENOPOMA.

II. NOTES ON THE BLOOD-CORPUSCLES OF NECTURUS.

By SIMON H. GAGE, Cornell University, Ithaca, N. Y.

It has always seemed to me worth while for American students to publish even small notes on characteristic American forms, if by so doing existing knowledge is increased or the statements and generalizations of European investigators, based almost necessarily, in great part, upon European material, may be corrected. The following notes are offered, hoping that they will answer one or both of the above requirements:

I.

In frogs, as is well known, a lining of ciliated epithelium covers the free surface of the mucous membrane of the mouth and œsophagus, and extends to or into the stomach. This is true also of a great many other Amphibia, and the generalization is made by Wiederscheim (*Lehrbuch der Vergleichenden Anatomie der Wirbelthiere*, Band II., page 583) and by Hoffmann, in the part, "Amphibia," of *Bronn's Klassen und Ordnungen der Thier-Reichs* (p. 383, 400), that a ciliated epithelium lines the mouth and œsophagus of all Amphibia (that is, frogs, toads and salamanders of all kinds).* Hoffmann, citing Leydig as authority, makes but a single doubtful exception. In the exceptional case, the epithelium is said to be, probably, ciliated with such fine cilia that they were not detected. Professor Owen (*Comparative Anatomy and Physiology of Vertebrates*, Vol. I., p. 435, 440) says, that ciliated epithelium is present in the mouth of most Amphibia and in the œsophagus of the triton, and of the larvæ (tad-poles) of frogs and toads.†

* As the structural indications of a division into mouth and pharynx or throat, in most Amphibia, are very obscure, if present, the alimentary canal preceding the stomach is, in this paper, considered to be divided simply into mouth and œsophagus; the beginning of the œsophagus being indicated by the narrowing lumen and the beginning of the longitudinal folds.

† The statement of Prof. Owen is very meager, and neither makes a generalization nor admits of one.

As the three authors named stand very high as original investigators, as the work of one of them (Wiederscheim) was published in 1883, and as no original work upon this subject has been done, so far as I know, since their publication, their statements may be taken as representing the present state of knowledge upon the subject.

In Necturus, one of the water salamanders with permanent external gills, found in all the larger lakes and streams west of the Hudson River, the lining epithelium of the œsophagus is columnar and ciliated, but that lining the mouth is not a ciliated, but a stratified, pavement or transitional epithelium. The cells are very large and irregular, and possess a large nucleus which show quite clearly what is considered by many writers to be an intra-nuclear net-work, and also a clear zone (nuclear membrane) separating the nucleus from the cell-body. In *Menopoma*—the large water salamander without gills, found in the Alleghany and Ohio Rivers—the structure of the epithelium of the mouth and œsophagus is as described for *Necturus*.

While the facts presented in this paper show the danger of generalization with reference to a specific structure or function, unless all the facts that may support or overthrow the generalization have been critically investigated; they also suggest what seems to be a fruitful field of inquiry, viz., to see what mode of life or general advancement in structure is accompanied by a ciliated epithelium, both in the mouth and in the œsophagus, as in the frog; and also the conditions under which the mouth is lined by a non-ciliated, and the œsophagus by a ciliated epithelium. The mode of life and the structural conditions in *Necturus* and *Menopoma* point to the generalization that while in all Amphibia the œsophagus is probably lined with columnar ciliated epithelium, the epithelium lining the mouth is columnar and ciliated in the forms living mostly on the land or on the surface of the water, and into whose mouth water only occasionally finds access (frogs, toads, many salamanders); while in those like *Necturus* and *Menopoma*, living almost exclusively under water like a fish, the epithelium of the mouth is non-ciliated and stratified.

II.

[The publication of this paper is deferred at the request of Prof. Gage.—PUB. COM.]

BUTTER AND FATS.

To Distinguish one Fat from Another by Means of the Microscope.

By THOMAS TAYLOR, M. D.
Microscopist to the Department of Agriculture, Washington, D. C.

[PLATE VI.]

A little over ten years ago I made my first experiments relating to oleomargarine and butter, my prime object being to find a mode by which I could distinguish these substances one from the other.

My first paper on this subject was illustrated by several cuts, and published in the New York *Quarterly Microscopical Journal*, as early as 1876.

My second paper was written in answer to a request of the Committee on Manufactures of the House of Representatives, during the session of 1876 and 1877, the committee having sent to the Commissioner of Agriculture two samples of a butter-like substance to be examined by the "microscopist" of the Department, with the request that he should decide whether the substance was butter or oleomargarine. I made the examination, and reported that both samples were oleomargarine. Soon afterward, two members of the committee called and examined my modes of detecting butter substances and substitutes, and expressed themselves perfectly satisfied with my report, they having been aware from the first that the samples sent by them were oleomargarine.

My third report on butter and fats was published by the Department last year (1884), and is illustrated by six cuts—chromo-lithographs.

There has been a considerable demand for this paper from various classes of persons, including dairy commissioners, milk inspectors, produce dealers, officers of boards of health, physicians,

professors in colleges and universities, microscopists, chemists, and others.

Since the publication of that paper, I have experimented largely with butter, and have made the discovery that when it is boiled and cooled slowly for a period of from twelve to twenty-four hours at a temperature of from 50° to 70° Fahr., it not only becomes crystallized, but with proper mounting and the use of polarized light it exhibits on each crystal a well-defined figure resembling what is known as the cross of St. Andrew. (*Fig. 7.*) In course of time, the period ranging from a few days to a few weeks, according to the quality of the butter used and the temperature to which it is exposed, the crystals, which at first are globular, degenerate, giving way to numerous rosette-like forms peculiar to butter. (*Fig. 9.*)

I have also demonstrated that the respective crystals of butter, beef, lard and other fats differ essentially from each other, and may be distinguished at once one from another when properly prepared. The crystals of newly-made butter when boiled are globular and present a dotted appearance, which may be due to the projection of numerous spines, so small as to be scarcely visible even with the high power of the microscope. Those of beef have long bi-serrated spines proceeding from a common center, while pressed lard gives a strictly stellar or star-like form proceeding from a dense opaque center which appears to be granulated. Boiled lard fails to show an opaque center.

These new facts led me to experiment with other fats, vegetable and animal, with a view to determining whether the fats of other animals and vegetables may not also have crystalline forms peculiar to themselves, and of such definite structure as might lead to their detection, when fraudulently combined with other fats, in medicinal compounds, etc. I have made numerous experiments to that end, and I find as a result of these investigations, that the normal crystals of several fats which have not heretofore been examined with sufficient accuracy, may be determined from all others thus far examined. For example, I find that cocoa butter, when its consistency is very much reduced with sweet oil by means of heat, gives a most beautiful and perfectly formed crystal. Spermaceti, white beeswax and paraffine, treated in the same way, give other forms,

but as yet I am unable to obtain the highest crystalline forms of these last mentioned fats.

The value of my investigations in animal and vegetable fats, may be inferred from the fact that in each of the prosecutions lately brought against fraudulent butter dealers and venders in the city of Washington, D. C., the accused in every instance acknowledged that my evidence against them was correct, and that they had sold tallow compounds as butter.

As a consequence of my success in detecting these fraudulent compounds, about sixty hawkers, men and women, who, under the guise of farmers, have been offering for sale from door to door in this city, compounds of tallow, lard and cotton-seed oil, mixed with inferior butter, as genuine creamery butter, have abandoned their calling, to the great benefit of the dairy interests of this section of the country.

General Examination of Butter and its Substitutes by the Naked Eye.

In making examination of butter and its substitutes without the aid of the microscope, I first place a specimen of the suspected article between two small pieces of glass, using for one the ordinary microscopic slide, 3 by 1 inch, and for the other a thick microscopic cover. I then compress the specimen sufficiently to give a thin, translucent cloud. If white, opaque particles are observed between the glasses, there is reason to believe that the substance is a foreign fatty compound. If the experimenter will first practice with lard, in an atmosphere of moderate temperature, he will observe the white specks of fat alluded to. Should the cloud be very even throughout, it is probably pure butter, or newly-made butterine.

Before using the microscope, I usually subject a portion of the samples submitted for examination to my sulphuric acid test. (See Sulphuric Test.)

While these two simple tests will always distinguish true oleomargarine from butter, their result is less decisive in the case of butterine, owing to its containing a considerable proportion of butter. Hence it is is often necessary to subject what appears to be genuine butter to a closer examination. When this is the case, I resort to the microscope.

Microscopic Test.

Prepare the sample by first removing any salt present by pressing a portion of the substance through the meshes of fine cambric muslin; then mount the specimen, with as little friction as possible, and view it by plain transmitted light, under a power of about 75 diameters. If well-defined crystals of fat are present they are at once seen. Should fat be in the amorphous state, it will not be observed in this way. I then resort to polarized light, when very minute, fatty bodies, whether in the amorphous or crystalline state, are at once detected, if present. For this purpose the polarizer is rotated until its face angle is at right angles to the analyzer. Push the polarizer down as low as the stand will permit; by this means a darker ground is produced, and the bright specks or light shades of fat will appear over the dark ground. When these amorphous fatty bodies are found, a selenite plate should be used in connection with the polarizing prism. With this combination a brilliant display of prismatic color will be seen. (*See fig. 16.*)

When it is desirable to ascertain whether they are of beef or lard, boil about one ounce of the substance, and cool it slowly. The next step is to examine a portion of it, thus prepared, under the microscope. When permanent specimens are desired it will be necessary to prepare, by any of the well-known means, on a glass slide of 1 by 3 inches, a varnish ring one one-hundredth of an inch in thickness. When dry, put a single drop of any thick, transparent oil within the circle, and place in contact with the oil a very small portion of the suspected substance. Use a needle, to separate the floating fatty substance into very fine granules (crystals). Place a suitable glass disc or "cover" over the oil and press it gently down, so that it will come in contact with the varnish ring, which should receive one coat of varnish just before the slide is used. The ring should be of sufficient thickness to protect the crystals from pressure by the cover. The object may now be viewed by plain transmitted light. If the crystals exhibit a well-defined stellar form, such as *figs. 13* or *14*, the substance is lard. If such as *18*, it is beef fat. But the latter should be viewed with the high power of the microscope with polarized light, so as to observe the bi-ser-

rated form of the individual spines, of which the perfect crystals consist. If butter crystals are present they can at once be distinguished.

How to Crystallize Butter and other Fats, and Separate the Crystals so as to be Seen with the Naked Eye, or Pocket Lens.

Procure a specimen of pure butter, and boil it in a test-tube or iron pan for a period of several seconds; pour the liquid portion off into a cup or other suitable vessel, and put it in a cool place to crystallize. I generally allow the cooling process to continue from twelve to twenty-four hours. Remove with the point of a penknife a few grains of the butter thus treated, place it on a slip of glass and pour over it a few drops of alcohol. The crystals may then be easily separated from each other by means of a needle. A solution of alcohol in a concentrated solution of pure carbolic acid, *i. e.*, the proportion of ten parts by measure of the first, to one part of the last, will prove more satisfactory in separating the crystals than alcohol alone. If the crystals are viewed by a pocket lens, they will appear like so many insect eggs. (*See fig. 1.*) Beef and lard fats may be treated in like manner, but in practice it will be found that the crystals of these fats are not so easily separated, owing to their long spines interlocking with each other. Treated in this way, the fatty crystals will be seen very well with a pocket lens.

About ten years ago, while making some experiments with boiled butter, I first observed it exhibited small crystals somewhat stellar in form, but gave no further attention to the fact until May last. For the purpose of determining the real form of the crystal of boiled butter, I procured a sample of pure dairy butter from Ohio. I boiled it, and, when cold, examined it under a power of 75 diameters. To my surprise I found globular bodies. When I subjected them to polarized light, a cross, consisting of arms of equal length, was observed on each crystal. (*See figs. 2, 3, 5, 6 and 7.*) On rotating the polarizer the cross of each crystal rotated. On rotating the glass on which the specimen of butter was mounted, the crosses remained stationary, thus showing that the appearance of the cross depends, probably, on the fact that the crystals are (1) globular, (2) polarizing bodies, (3) translucent, and (4) comparatively smooth. Were they opaque or non-polarizing, or did they

consist of long spines, causing great divergence of the rays of light, no image of the cross would be visible; showing that the appearance of the cross under polarized light and the conditions stated are not due to any physical cross structure on the fatty crystals themselves. But from whatever cause the appearance of the cross on the butter crystals arises, its constant appearance on new butter under the conditions above described is a fact beyond any question; and, as far as my experience goes, the better the quality of the butter the more clearly defined is the cross: it is black, large and well defined. When these crystals are under polarized light and a selenite plate, combined, they exhibit the prismatic colors, but the cross proper is not visible in this case, although the crystals are still divided into four equal parts and are exceedingly interesting objects. (*See fig. 10.*)

In order to leave no room for doubt respecting these globular crystals being peculiar to butter, I had cream churned through the kindness of Mr. Frank K. Ward, of this city, and a fine sample of granulated butter made in my presence, a portion of which was secured, also a portion of butter from another lot made in my absence. The first lot was made of pure Alderney cream, the second from mixed cream. The samples were kept apart in separate boxes, boiled, cooled slowly, and examined after my usual modes. Both samples gave the globular crystals, showing the cross. These crystals varied in diameter from fifteen ten-thousandths to one one-hundredth of an inch. Large crystals, such as the latter, show the cross but dimly, while the small ones show it distinctly.

The Butter of Several States Examined.

To this date I have received several samples of butter from Tennessee, Ohio, New York, Maryland, Virginia and the District of Columbia. All exhibited one or both forms of the crystals common to butter, but generally the globular only. Pure market or store butter which has been exposed to high temperature for several months, exhibits a greater number of the rosette forms, measuring only about fifteen ten-thousandths of an inch in diameter. In general it may be said that as butter loses its freshness, either through age, heat, or other cause, the globular crystals of boiled butter seem to bud or send forth a small rosette crystal appearing always in the

center of the globule. (*See fig. 5.*) Inferior butter appears to resolve more quickly into the rosette-like forms than the highly fatty butters of the best quality. (*See figs. 8 and 9.*) These latter forms appear to result from the breaking up of the globular crystals, in the center of which speck after speck will appear to expand into the rosette shape, and float away in the oil in which they are mounted. (*See figs. 5, 8 and 9.*) In examining the two butters received from Mr. Ward, I observed they differed materially from all others received; the crystals being darker in color generally, and larger.

The butter received from Franklin Brothers, Jefferson County, Tennessee, exhibited a peculiar indentation in the large crystals; and so well defined is this peculiarity that this brand may at once be distinguished from all others I have yet examined. (*See fig. 6.*) All butters examined in May last, made from milk of cows fed on dry feed, exhibited crystals more brilliant in appearance than those fed on grass in July, August and September, and contained more solid fat. I think it probable that the butter crystals of different breeds may yet be distinguished from each other by some marked peculiarities, although preserving, always, well-defined features common to butter.

The globular crystals of butter, grass fed, are exceedingly transparent; in this case a very low power of the microscope should be used for examinations. I have found an inch-and-a-half objective answers the purpose.

Exceedingly small globular butter crystals may arise from one or two causes, such as using very oily butter, or by cooling the boiled butter too quickly. All boiled samples should be kept in a dark cool place, to prevent the crystals from passing to the secondary stage, characterized by the rosette forms. Should these precautions be neglected, effective crystallization will not take place, and the cross will not be easily discovered. At high temperatures, say 100° Fahr., the globular crystals of butter generally dissolve.

Mounting Butter Crystals.

A practical microscopist will readily perceive that from the very nature of the crystals great care must be exercised in mounting them. The globular crystals should not be compressed; neither should they be exposed to light, except when necessary, or to a

temperature of over 70° or 75° Fahr. At 95°, I found the crystals of the Franklin, Tennessee, butter dissolve, while the "Ward butter" crystals at the same temperature retained very nearly their normal form.

In order to cystallize solid fats, such as beef, and show their normal crystals, it is necessary first to boil them with sweet oil. When cold, the composition should be of the consistency of butter. Cocoa butter and the fat of the tallow tree of China should be made so liquid, when cold, that its crystals will swim incrusted on the surface of the oil; this will take place always, provided the oil, while hot, is saturated with the tallow. When a little of this floating incrustation is bruised gently in oil and mounted, beautiful crystals will appear under the microscope. Normal crystals of fat of any description mounted in oil are difficult to preserve for a long period, owing to their tendency to dissolve in the oil in which they are mounted, especially at temperatures exceeding 80° Fahr.

Sulphuric Acid and Other Tests for Butter, Oleomargarine and Butterine.

Oleomargarine made under the French patent, consisting mostly of beef fat, is easily detected by pouring a few drops of concentrated sulphuric acid on a portion about the size of a bean, and mixing them quickly with a glass rod. The mass at once assumes a light amber tint, soon turning darker and richer in color. After a period of from fifteen to thirty minutes it turns to a well-defined crimson-scarlet; after a lapse of twenty-four hours it becomes the color of dark walnut, and remains of that tint. Within the last six months I have failed to find any of this grade of butter substitute in Washington markets. It is giving way to various cheaper compounds, known as butterine.

True oleomargarine may be detected also by boiling a sample of it in an iron spoon, when the odor of burnt fat is given off. Butterine cannot be detected by this process satisfactorily, owing to the presence of butter in the mixture, the butyric acid of the butter being the most prominent odor observed.

If samples of pure butter, oleomargarine and butterine are exposed to a temperature of 75° Fahr. for a period of one hour, the last named will become slightly glossy, and at 85° will become almost semi-fluid, while the other two samples named will not appear, to

the naked eye, to be thus affected, and will preserve their sharp angles.

When oleomargarine or butterine is newly-made, crystals of fat are seldom observed in it, when viewed under the microscope; but in course of time, owing to their being subjected to light, and increasing rise of temperature in the stores, both exhibit crystals of fat more or less. In the butter substitutes of commerce, the crystals are seldom absent, and dark, nitrogenous, yellow, translucent bodies are always seen in them and are characteristic of them. These latter substances are never found in pure butter. When a butter substitute is sold as butter, and exhibits only the faint odor and taste of butter, and one is puzzled to know whether it is genuine or not, it will generally prové to be either oleomargarine or butterine. When the suspected substance has a bad odor and tastes like butter, it is probably old butter, provided it exhibits no dark yellow bodies when viewed under a power varying from 75 to 250 diameters.

How to Detect the Crystals of Lard by the Eye, Unaided by a Lens.

Procure a piece of glass. Place a small portion of the lard upon it, covering it with a thick microscopic glass disc; press the parts together so as to form a thin film of the lard between, as described in the case of butter. View the glass and lard thus secured before a strong light, when white specks will be observed in the lard. The transparent portion represents the oil—the white specks the crystals of fat. In this way, fats may frequently be detected in oleomargarine and butterine. Pure butter treated in this way exhibits a plain even cloud. Mixed butters have a streaky appearance, owing to their different densities and colors.

General Notes.

Oleomargarine when made under the formula of the French patent, is composed mostly of beef fat churned with milk and colored with annotto. Very little of this composition is now manufactured in the United States; it is giving way to butterine.

Butterine is said to be composed of lard four pounds, tallow four pounds, and creamery butter two pounds. A lower grade is made as follows: Cotton-seed oil, four pounds; tallow, four pounds; low grades of butter, two pounds. It will be seen from the two

compositions of butterine above quoted, that the sulphuric acid test would act differently in each case. I, therefore, advise the polariscope test as the most effective for these compositions, boiling all samples, after having tested the sample as found in the market for sale. In this way all of the fats contained in the sample will be crystallized. These should be examined as described.

A composition of butter and lard sold as oleomargarine, but in reality butterine, was sent to me and examined. In this case the butter used was probably in larger proportions than the lard. When viewed by polarized light only, it exhibited the cross of pure butter, while the crystals were covered with the spines of lard modified by the butter. (*See fig. 11.*) With selenite plate it appeared like *fig. 12.*

All butter and fats when boiled, should be strained while hot, to remove coagulated albuminous bodies.

Illustrations of Fatty Crystals. Butter, Lard, Beef, Oleomargarine and their Imitations.

Fig. 1. Represents a number of boiled butter crystals as seen by a low power.

Fig. 2. A crystal of Tennessee butter, boiled, as seen under polarized light, showing the cross of St. Andrew. Breed, Tennessee native, and shorthorn Devonshire.

Fig. 3. A crystal of Ward's "Alderney" butter, boiled, Washington, D. C.

Fig. 4. A crystal of butter highly magnified, boiled.

Fig. 5. A crystal of Tennessee butter, boiled, exhibiting the second stage of crystallization in progress. See small rosette crystals growing from center of globose crystal.

Fig. 6. A crystal of Tennessee butter, boiled, exhibiting an indented crystal, a peculiarity of this butter.

Fig. 7. A crystal of Ohio butter, boiled (Huron County); color, white.

Fig. 8. Secondary rosette crystals of boiled butter as seen under polarized light and selenite plate.

Fig. 9. Secondary rosette crystals as seen by polarized light without selenite plate.

Fig. 10. A crystal of boiled butter as seen under polarized light and selenite plate.

Fig. 11. A crystal of boiled butter and lard combined, sold as oleomargarine. The cross represents the presence of butter, the spines that of lard, as seen under polarized light.

Fig. 12. A crystal of the same compound (butterine), as seen under polarized light and selenite plate.

Fig. 13. A crystal of pressed lard, with dark center.

Fig. 14. A crystal of boiled lard, strained.

Fig. 15. A crystal of boiled lard, strained, as seen under polarized light and selenite plate.

Fig. 16. Oleomargarine or butterine, as seen under polarized light and selenite plate. The fat in this case is in a homogeneous state.

Fig. 17. Specimen of pure butter, free from salt or other particles, as seen under polarized light and selenite plate. In this case the shade of color depends on the selenite plate. It may be red, green, blue or other color, but will always have an even shade in the case of pure butter.

Fig. 18. A normal crystal of beef fat, very highly magnified. The crystals of beef vary in structure, but they preserve uniform characteristics.

All the butters illustrated in this plate have been made from the milk of dry-fed cows.

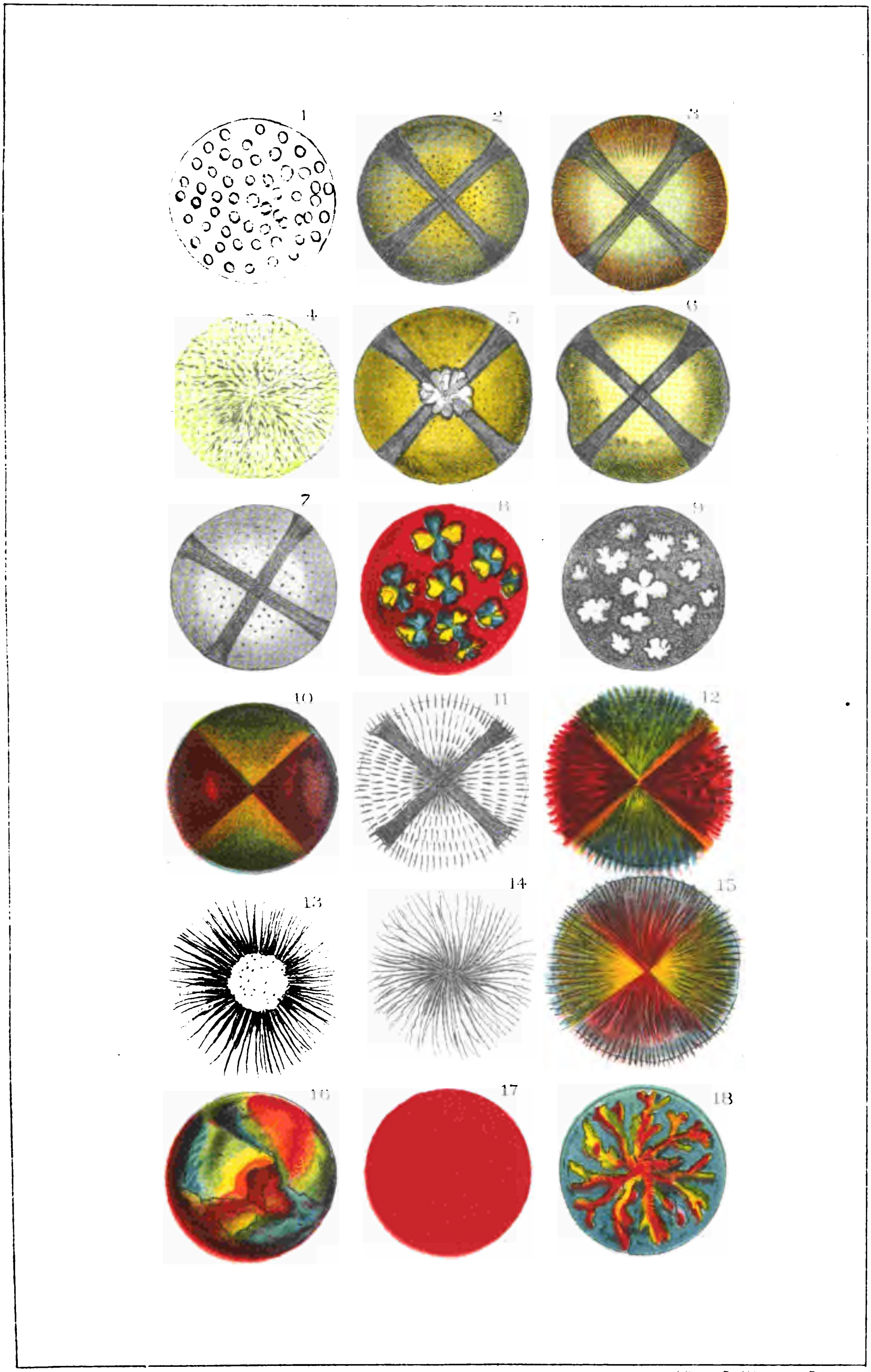
When cows are fed on green feed, the butter is more oily; in this case, the cross is not so well defined under the conditions stated. Very oily butter should be viewed under a power of about twenty diameters. In this way the cross will be seen. They will rotate or appear to do so, on rotating the polarizer or analyzer.

Beef fat, reduced to the consistency of butter by heat and the admixture of sweet oil, and cooled, when viewed by plain transmitted light, will appear as simply mottled, brown nitrogenous bodies, destitute of structure; but when viewed under a power varying from 500 to 1000 diameters will give defined crystals, resembling *fig. 18*, more or less, having branched spines, serrated and bi-serrated.

My discovery that the respective fats of animals and vegetables differ so essentially from each other, opens up a new field of investigation, and gives great promise of future discoveries in this line.

CRYSTALS OF FATS, BUTTER, BEEF & LARD,
Representing Butter, Oleomargarine & Butterine.

PLATE VI.



Thomas Taylor, del.

A. Hoen & Co. Lithocaustic, Baltimore.

REMARKS ON STEPHANODISCUS NIAGARÆ.

By C. M. VORCE, F. R. M. S., Cleveland, O.

The conclusions of Gov. Cox [see paper at page 33] are corroborated by some observations made by myself a few years since, I think in 1879, on a diatom very common in the water supply of all the cities on the great lakes, viz., the *Stephanodiscus Niagaræ*. This is a familiar diatom, and in its normal state the frustule has considerable depth, about $\frac{1}{3}$ the diameter of the valve. As gathered in its fresh living state the endochrome in this diatom is very distinct and is plainly seen to line the surface of the two valves with a thick layer, while a stout central cord connects these two valve layers into one mass. This condition, the normal mature state of the diatom, is shown in *fig. 1.*

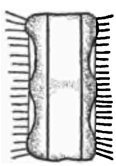


Fig. 1

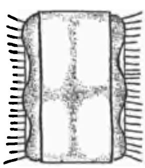


Fig. 2

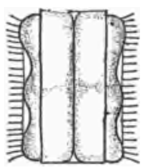


Fig. 3

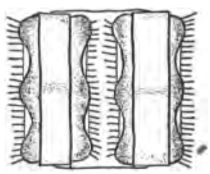


Fig. 4

By examining continuous series of gatherings, daily, or nearly so, the entire process of division can be seen in this diatom. The first change noticed is that the connecting zone or hoop is widening. Whether the growth of the hoop during this widening takes place along the edges only, or otherwise, I do not know, but certain it is that this hoop widens out and the box of the frustule becomes consequently deeper until it is often as deep as it is wide. Contemporaneously with this growth of the silicious wall of the frustule the endochrome increases in quantity, and as the time for division comes on forms a central mass, which finally extends to the outer wall, so that now in addition to the thin layer lining all the interior

of the frustule, there are three main masses of the endochrome, one spread over the inner surface of each valve and another occupying the center of the frustule. *Fig. 2* shows this condition of the diatom.

Up to this time there is nothing to be seen of the silicious walls except the outer walls of the original frustule; but at about this time there will suddenly be discovered an extremely fine line of division crossing the center of the frustule in the middle of the central mass of endochrome. This is almost invisible at first, but gradually becomes more distinct as it thickens and grows stronger. At first it is soft and flexible, and is undoubtedly a vegetable membrane devoid of silex, or nearly so: in frustules pinched by the cover as the water evaporates, this membrane is often seen bulged out by the pressure of the fluid contents of the frustule, especially if one valve be broken. Later on, as this membrane thickens, it shows double at the outside of the frustule. *Fig. 3* shows this condition, and finally it becomes double clear across the frustule, and begins to exhibit indications of the future spines of the new valves. The frustule has now become double, composed of two frustules, each of which has its outer valve thick and strong with long spines, and its inner new valve thin and fragile, with only rudimentary spines. The endochrome in each of the frustules is disposed as it was in the original frustule before division began.

As growth in the new valves goes on, they become, of course, thicker, and separate from each other further and further, being apparently pushed apart by the growth of the lengthening spines, until finally they are sometimes half as far apart as the width of the original frustule. The hoop of the parent frustule goes on widening to accommodate this growth until when the two new frustules are completely grown and "ripe," so to speak, they present the appearance shown in *fig. 4*, and are ready to separate and repeat the process each for itself. One or both of the new frustules now drops out of the hoop, and it is not uncommon to find the wide hoop with one frustule attached and one gone. The separate hoop is also sometimes found, but I have never seen a frustule beginning division with the old hoop attached, nor any approach to the formation of a chain as in Melosira. In fact, so far as my observations go, *fig. 1*

is the beginning and *fig. 4* the end of the cycle of growth and division. I do not know whether these observations are new or not; but I submitted them and my views concerning them to Prof. Smith, now our President, at the time they were made, and he agreed with me fully in the respects I have stated here, although he did not concur in my suggestion that *Actinocyclus Niagaræ* might perhaps be the sporangial frustule of *Stephanodiscus Niagaræ.* However that may be, the point to which I cite these observations is that in the division of the frustule in this diatom, S. *Niagaræ*, the new valve is formed by the deposition of silex from the fluid of the frustule contents or from the surrounding water in or upon a membrane previously formed, and not by growth along an edge; and if this is so in the case of the valve it may naturally be so in the case of the connecting zone or hoop.

THE CULTIVATION OF BACTERIA, AND THE CHOLERA BACILLUS.

By LESTER CURTIS, M. D., F. R. M. S., Chicago, Ill.

In order to be sure that a disease is caused by any germ, five conditions must be fulfilled. (1) It must be found in the blood or tissues of every one affected with the disease. (2) It must not be found in the body of persons not affected with the disease. (3) It must be cultivated outside of the body in such a way as to ensure its freedom from other forms, and for generations enough to be sure that it has been freed from any other poison contained in the body. (4) This pure culture must then be inoculated into the body of some other person, and the original disease must result. (5) The germ must be found in the last case. If any one of these steps is wanting, the proof of the causation of the disease is incomplete.

The detection of the germ in the body of the diseased person is, for the most part, comparatively easy, and is well enough understood; but if we may judge from much that has been written lately on the cholera bacillus, the second step is by no means so well-known.

There are two methods of culture in use: the culture in fluids, and that on a firm soil. Culture in fluids has several disadvantages. In the first place, any part of the body to which air can gain access will contain several forms of bacteria, as in the case of pus from an ulcer, sputum, etc. It is impossible in fluid cultures to separate these forms and detect which one is the cause of mischief. But even if pure in the first place, it is difficult to keep cultures entirely free from contamination from germs contained in the air, and other sources. In fluid cultures, on account of the mobility of most forms, these impurities become thoroughly mixed with the original forms, and it is impossible to distinguish one from the other. Indeed, many forms are inimical to each other, and the intruders may de-

stroy the original forms and leave something entirely different in their place. Dr. Koch has, therefore, devised his method of cultivation on a fixed soil. Several substances are used for this purpose, but the most common are peptonized beef broth mixed with gelatine, and the potato. The bacteria are unable to move on these materials, and if an impurity finds its way into the culture it can be detected and removed. The preparation of peptonized gelatine is as follows: 250 grammes of fresh beef, as free as possible from fat, is chopped fine, placed in 500 grammes of distilled water, and allowed to stand over night upon ice. The mixture is then shaken repeatedly and pressed through a fine cloth; distilled water enough is added to make 400 cubic centimeters; to this, 4 grammes (1 per cent.) of "*Peptonum Siccum*," 2 grammes of common salt and 40 grammes of fine white gelatine are added. This mixture is allowed to macerate for about half an hour, and is then warmed in a water bath so as to melt the gelatine without precipitating the albumen. It is then carefully neutralized with a saturated solution of bicarbonate of soda, adding the solution, drop by drop, until blue litmus paper remains blue, but red paper shows a slight blue tinge. For the cholera bacillus this neutralization must be very carefully done, for the bacillus will grow only when the exact stage of neutralization is reached. In case the mixture has become too alkaline, a little lactic acid should be added. The mixture is then boiled from half an hour to an hour, in order to precipitate the albumen; filtered, and if not quite clear, boiled and filtered again. It should then be tested again to make sure that the reaction has not changed, which it is somewhat liable to do. By this cooking the color of the mixture is changed to a faint yellow. After boiling, the mixture is filtered into a microscopically clean vessel and again boiled until no cloudiness appears. It should then be clear and of a topaz-yellow color. The mixture may be preserved in test-tubes which have been stopped with cotton and steralized by heat. In laboratories it is usual to have an oven, which can be kept at a uniform high temperature, for this purpose. The temperature required to be maintained is from 160° to 180° centigrade, continued for an hour. Large numbers of test-tubes can be so steralized very conveniently. The oven is, however, by no means necessary. If the tube is cleaned

and a plug of cotton placed in the mouth, it can be easily steralized by heating in the flame of a Bunsen burner, or alcohol lamp; taking care, of course, in order to avoid burning the plug, to push it into the mouth of the tube a short distance with the points of forceps *which have been heated.* If the cotton is heated just enough to brown it slightly, it is sufficiently steralized. The test-tube itself is steralized if heated all over so that it feels warm when held close to the face. The tubes are then filled about one-third full with the peptonized gelatine. A pipette with a bulb in the middle, which has been steralized by passing through a flame, is convenient for this purpose. They are then placed in a vessel of water, first putting six or eight layers of muslin under them to prevent their breaking, and boiled a quarter of an hour, or more. The ebullition should not be rapid enough to bring the gelatine in contact with the cotton, or it will be difficult to withdraw the plug when desired. This boiling is repeated at intervals of from twelve to twenty-four hours, for five or six times; the reason of this repetition in boiling being that adult germs are destroyed by a temperature of boiling water, but many spores are not. By the first boiling, the adult forms that may have found their way into the gelatine, will be killed, but if any spores are present they may remain alive. In from twelve to twenty-four hours these spores will have begun to develop adult forms, which will be killed by the boiling before they have had time themselves to form spores. After five or six of these boilings it may be safely concluded that all the spores that are to develop at all, have done so, and that the mixture is steralized. As a further precaution, however, it is desirable to keep the tubes a few days before using, in order to see that no forms develop in them.

Having secured the steralized gelatine we are prepared to begin the cultures. These cultures are of two sorts: plate cultures and needle cultures. Plate cultures are for the purpose of securing the germ in a pure state. For this purpose there are provided a series of glass plates about four inches by six, and some benches made of strips of glass about six inches long and two inches wide, to the ends of which have been cemented strips of glass about one-quarter of an inch in thickness. In order to protect these plates from dust the laboratories are provided with flat and low glass shades, similar

to the cake covers used by confectioners, which fit into shallow glass vessels—these are called moist chambers. If these are not at hand, however, the confectioner's cake cover and a dinner plate, or even two soup plates, will do very well. A platinum wire about one and a half inches long, melted into the end of a glass rod, and a similar one bent into a loop at the end, and an ordinary glass stirring-rod are also necessary.

The bell glass is now washed out with a solution of corrosive sublimate (1 in 1000), and a layer of filter paper moistened with the same solution is placed in the bottom of the moist chamber. The plates are then passed through the flame of a Bunsen burner or an alcohol lamp, laid upon blotting paper on the table, and covered with the bell in order to cool. Three or four, or more, of the test-tubes containing the steralized gelatine are warmed sufficiently to melt the gelatine, and the cotton plugs are loosened to make sure of their easy removal. The platinum needle with the loop upon the end is passed through the flame and allowed to cool. The test-tube containing the gelatine is taken between the thumb and forefinger of the left hand with the palm turned obliquely upwards. In order to prevent dust falling into the open end, the tube is inclined as much as possible without the gelatine touching the cotton. A small flocculus of mucus from the cholera stool, about the size of a pin's head, is then taken up with the platinum wire; the plug of cotton is removed from the test-tube by the third and little fingers of the right hand, and the mucus is introduced into the gelatine, and thoroughly mixed by stirring with the needle. The plug is returned to the tube, and the tube is shaken to ensure the more perfect mixing of the whole. A little wetting of the cotton in this case does no great harm. Another tube of gelatine is then taken, prepared as before and placed between the first and second fingers, while the first tube is held between the thumb and first finger as before. The plugs are then removed from the tubes and placed respectively between the second and third, and third and fourth fingers of the left hand, taking care to touch only the upper part of the cotton. Five drops are then taken from the first tube, with the platinum wire, and placed in the second tube giving the wire a little shake each time to ensure the detachment of the drop. These drops are

also thoroughly mixed with the gelatine as in the former case. A third tube is prepared by taking, in the same way, five drops from the second tube. The gelatine in the tubes is allowed to cool to a point where it is just about to stiffen but is still fluid enough to flow, and is then poured out on the plates and, if necessary, spread around with a steralized glass rod, leaving a rim about half an inch wide at the edges. The plates are then piled, one over the other, upon the glass benches in the lower part of the moist chamber, first putting under each plate, upon its bench, an appropriate label. The object of this whole procedure is to spread the germs over a considerable surface by diluting the fluid in which they are held. They can be so spread that the individual germs will be separated from each other by an interval of half an inch or more, and the growth of each germ can be studied by itself, under the microscope, and the particular sort that is wanted can be fished out with a steralized platinum needle. In order to ensure the perfect freedom of the germs from any mixture, it is advisable to repeat the culture two or three times. When this has been done it is quite certain that the culture is pure. Minute directions for picking up these colonies are given in the laboratory. The needle is bent into the form of a small hook, about a millimeter in depth, before being heated. The plate is then placed upon the stage of the microscope, and a typical colony selected, a low power—an inch or three-quarters—being used. The little finger is rested upon the stage, the needle is brought into view over the colony, the point of the hook is then lowered into the colony and again raised perpendicularly upwards and removed.

Having the pure plate culture, we are in a condition to make the needle culture. This is done by picking up one of the colonies on the plate with the platinum needle and plunging it nearly to the bottom of the cold gelatine in one of the tubes, and studying its method of growth in this situation.

While the culture is going on in the gelatine, it is also desirable to study the growth of the forms in the "hanging drop." A slide which has been hollowed out to the depth of from one to one and a half millimeters is needed for this purpose. The slide is cleaned and passed through the flame. After cooling, a ring of vaseline is run around the edge of the exca-

vation. Too much vaseline must not be used or it will prove troublesome by running under. A cover is also cleaned and heated. A drop of the peptonized beef without the gelatine is placed in the middle of the cover, and a small portion of the cholera mucus is rubbed into the drop without spreading it. The cover is then quickly inverted over the chamber, being careful, of course, that the drop does not reach the sides of the cell: the process of growth may now be studied under high powers.

The culture upon potatoes is made in the following way. A potato that is soggy when boiled, and one as round and smooth and free from defects as possible, is selected. This potato is carefully cleaned with soap and water and a brush, and all defects are scraped away with a knife, with as little injury to the skin as possible. It is then soaked for an hour in a half per cent. solution of corrosive sublimate and then steamed for half an hour. The blade of a dissecting knife is passed through the flame, and allowed to cool with the blade projecting, edge upwards, over the side of a table. The left hand is then dipped in a solution of corrosive sublimate (one part in a thousand) and the potato is taken up with the thumb and finger of this hand. It must never be touched with the other hand. The knife is taken with the right hand and passed nearly through the potato, and withdrawn without separating the halves, leaving a small portion of the skin so that they will not fall apart. The potato is then laid down in the moist chamber, which has been prepared as in the former case, and covered with the bell glass. A little of the infected material is then taken up on the point of the knife; the halves of the potato are for the first time separated, and the material spread over one half, as butter is spread upon bread, taking pains to spread the material evenly and not to bring it quite to the edge. A bit taken from the first half is then spread upon the other half of the potato. The dilution may be carried on in the same way to a second or even a third potato.

The cholera bacillus was discovered by Koch in the stools of persons suffering from cholera. In a hundred cases of this disease it was found always present and always the same. In its living condition it resembles somewhat the ordinary bacterium termo, but instead of being straight, it is curved not far from a quarter of a circle;

often two or more are connected together, sometimes forming a semicircle when the concave surfaces point the same way; or an old-fashioned long S, when they point different ways. Occasionally they form a wavy line. When sown upon plates, the cholera bacilli grow rather slowly; the colonies which form here and there over the plate very soon acquire a notched outline which is characteristic. The color of the young colonies is a light yellowish red, and the individuals are strongly refractile, so that the whole appears coarsely granular and as though composed of fine bits of broken glass. The gelatine is liquefied into a funnel-shaped excavation, broader above and smaller below. After five or six days the gelatine on the plate is not all liquefied.

In the needle cultures the upper part of the track of the needle begins to liquefy in a funnel shape, and in a day or so an air-bubble appears at its top. The lower part of the track of the needle appears as a fine white thread. It takes from four to six weeks for the whole gelatine to become liquefied. No offensive gases are formed, the extent of odor being a slightly pungent smell, resembling urine.

The bacillus will grow upon potatoes only at a temperature of about 37° centigrade, forming a dark-brown layer.

The bacillus does not form spores, and is not found in the blood or in any organ of the body except the mucous membrane of the intestine. It does not grow in acid fluids, consequently persons with vigorous digestions are not liable to cholera. It is only persons whose digestion is temporarily arrested who are liable to the disease, as is shown in the history of epidemics.

Giving the bacilli to the lower animals by the mouth has not caused the disease, owing, no doubt, to the great activity of their digestions. It is well known that they are not subject to cholera, probably for this reason. Injections into the intestinal canal, however, have given rise to symptoms exactly resembling cholera, with large numbers of the bacilli in the stools and in the intestinal canal.

Several forms which resemble this bacillus have been described; for, of course, every crooked bacillus attracts attention now. The most noted of these is that discovered by Finkler and Prior in the stool of a patient with cholera morbus. This bacillus was described, as being exactly like the comma bacillus of Koch, and consequently

attracted a great deal of attention. It must be borne in mind that it is in no way characteristic of cholera morbus, being never found in the fresh stools. This form was discovered in an old stool that had been exposed to the air for fourteen days, and all the bacilli of this kind which are known, have descended from this sample. In the dried preparation on the slide these bacilli resemble Koch's bacilli, but are larger in every way, and especially thicker. In the living state this difference is much more plainly marked. But cultivation shows other and widely different characteristics. In plate culture the plates soon acquire a distinct, brownish yellow color in place of the yellowish red of Koch's bacillus. The colonies have a sharp outline and a *fine* granular appearance. In about twenty-four hours they are surrounded by a broad zone of liquefied gelatine. The colonies soon break up into an irregular plate and the culture gives rise to an exceedingly offensive odor. In three days, at the longest, the gelatine is all liquefied.

In needle cultures the gelatine begins to liquefy at once the whole length of the puncture, and in a day or two a large coarse depression is excavated in the gelatine, not so funnel shaped as in the case of Koch's bacillus, but many times larger, and wanting the bubble of air. In a few days the whole of the gelatine is liquefied. On potatoes, the Finkler-Prior bacillus grows luxuriantly at the ordinary temperature of the room, forming a nasty, slimy, greyish yellow coating with a whitish bounding zone, and rapidly eats into the substance of the potato. These differences seem to be quite sufficient to show that the two forms are not the same.

Two other sorts of comma bacilli have been described: one sometimes found in the mouth, and another in old cheese. The bacillus from the mouth, in spite of Klein's assertions, will not grow on the alkaline gelatine. The bacillus of cheese will grow on gelatine, but in a way different from the cholera bacillus, and is not pathogenic.

The proof that the bacillus is unlike any other form and is peculiar to cholera, seems conclusive. That it is the cause of the disease seems to me scarcely less so.

A practical conclusion or two, and I have done. The disease is not contagious as small-pox and measles are; it is only by the bacillus gaining access to the intestinal canal that the disease is caused.

If this is prevented, one may go with impunity among cholera patients.

The bacillus does not grow in acids, consequently when the digestion is active, the chances of taking cholera are small. It is only at the times when the stomach has ceased to act, as during attacks of indigestion from whatever cause, that cholera comes on. Persons in good health, who have firm nerves and lead correct lives, suffer little from cholera. The timid, the weak, and the dissipated are its principal victims.

The bacillus grows freely in water and on damp surfaces, consequently during an epidemic, raw fruit and vegetables should be avoided, and everything that is eaten should be freshly cooked.

The bacillus forms no spores, and is not found in the blood, consequently inoculation is not only useless, but positively dangerous, from the liability of introducing noxious substances into the blood.

The germ is easily killed. A ten per cent. solution of carbolic acid for twenty-four hours will kill the germs on any article of clothing. A solution of corrosive sublimate will do the same thing in a few minutes if the garment is thoroughly wet with it. Superheated steam for half an hour will do it, perhaps, the best of all. If a cover glass containing the bacilli be allowed to dry for three hours, they cannot be again revived; consequently, even drying may kill them. Fumigations are of doubtful utility. Cold checks their growth, but does not kill them.

We may hope, then, to stop every epidemic with the first case, if the diagnosis is made early, and the patient is isolated, and thorough disinfection practiced.

DETERMINATION OF THE ABSOLUTE LENGTH OF EIGHT ROWLAND GRATINGS AT 62° FAHR.

By William A. Rogers, F. R. M. S.
Harvard College Observatory, Cambridge, Mass.

In January of the present year, the writer received from Professor Rowland eight diffraction gratings, with the request that the absolute distance between the terminal lines should be determined with great precision, with reference to their use in the measurement of absolute wave lengths. Four of these gratings were five centimeters in length, and the remaining four had a length of one decimeter.

The first step in the standardization of these gratings consisted in the establishment of definitely determined units of comparison upon bars of speculum metal having the same composition, and presumably the same coefficient of expansion as the metal upon which the gratings were ruled.

In any comparison of units of length it is important that the conditions under which the observations are made, shall differ as widely as possible. This diversity is not conducive to a close agreement of the individual results obtained, but the final mean will be nearer the truth than when the comparisons are repeated under substantially the same conditions.

Accordingly, in this series of observations, aliquot parts of a meter at 62° Fahr. were laid off upon three bars of speculum metal. They were made by Mr. Brashear of Pittsburgh.

Bar No. 1, which is 52 centimeters in length, has three sets of metric and three sets of English graduations, designated S^a_0, S^b_0, S^c_0. The metric graduations consist of 50 centimeters with triple lines for the decimeters. The lines of S^a_0 have about twice the width of the lines of the gratings; those of S^b_0 are a little finer than the average width of the lines of the gratings; while those of S^c_0 have about the same width.

Bar No. 2, designated $\dot{S}_1$ is 23 centimeters in length, and is graduated to 20 centimeters. The width of the lines is somewhat less than that of the finest lines of S_0.

Bar No. 3 is 27 centimeters long, and has 20 centimeter graduations. The lines have about the same width as those upon $\dot{S}_1$. This standard is designated $\dot{S}_2$.

The ultimate standard to which all comparisons are referred in this discussion is the bronze yard and meter $\dot{R}^2_2$ described in my paper, Studies in Metrology; Proceedings of the American Academy, Vol. XVIII., pp. 287–407. The steel standard $\dot{R}^2_1$, also described in this paper, was originally an end-measure only. It was purchased in Paris of the celebrated mechanician M. Froment. The line graduations were added by the writer. This standard is now the property of the Sheffield Scientific School of Yale College.

The relations of standards $\dot{R}^2_2$ and $\dot{R}^2_1$ to the Metre des Archives and to the Imperial Yard of Great Britain, described in my memoir, are derived from all the data at hand when my memoir was published. Since that time additional data bearing upon the subject have been obtained. It will be remembered that the relation was derived from a yard and meter laid off upon a bar of bronze having the same form and dimensions in cross section as the Imperial Yard.

A *B* *C*

Representing the yard by the line *AB*, and the meter by the line *AC*, the operation consisted:

(*a*) In the determination of the length of *AC* in terms of the Metre des Archives, A_0 through a comparison with a meter upon copper traced and standardized by Tresca and with a meter upon brass belonging to the Stevens Institute and compared with Type I of the International Bureau of Weights and Measures at Breteuil by Dr. Benoit.

(*b*) In the determination of the length of *AB* in terms of the Imperial Yard through comparisons with "Bronze 11" belonging to the United States Coast Survey and with a yard upon brass belonging to the Stevens Institute which has been compared directly with the Imperial Yard by Mr. Chaney, Warden of the Imperial Standards.

(c) The determination BC in terms of either AB or AC.

Under these divisions the following additional data have been obtained:

(a) In my paper, Studies in Metrology, Proceedings of the American Academy, Vol. XVII., p. 382, the following relations are given:

From a comparison of the bronze meter R_2 and the steel meter R_1 with the Tresca meter T, designating the Metre des Archives by A_0, we have:

$$\overset{a}{R}{}^{2}_{1} - A_0 = -3.2\mu.$$

$$\overset{a}{R}{}^{2}_{2} - A_0 = +1.5\mu.$$

From a comparison of the meters R_1 and R_2 with the Stevens Institute meter designated C S,

$$\overset{a}{R}{}^{2}_{1} - A_0 = -2.5\mu.$$

$$\overset{a}{R}{}^{2}_{2} - A_0 = +1.1\mu.$$

The values of the coefficient of expansion for the bars T, C S, R_1 and R_2 were found as given on page 380, viz.:

For T,	coefficient	for	1°C.	$=16.18\mu$.
For C S,	"	"	"	$=17.60\mu$.
For R_1,	"	"	"	$=10.11\mu$.
For R_2,	"	"	"	$=17.17\mu$.

The length of the meter C S was derived from the provisional relation communicated by Dr. Pernet, viz.:

$$CS \text{ at } 0°C. + 310.0\mu = A_0.$$

The coefficient of expansion of this metal determined at Breteuil had not been communicated at the time of the publication of my paper. It was, therefore, necessary to use the value given above, viz., 17.60μ in the reduction to 16.67° C. or to 62.0° Fahr.

In February last, I received from Dr. Pernet not only the exact observed relation between C S and Type I of the Bureau, but also the adopted value of the coefficient for this bar. The following are the relations communicated:

$$CS + 310.7\mu = A_0.$$

Coefficient of $CS = 17.71\mu$ for each degree C.

Substituting these values for those originally employed, we have the following relation between R_2 and A_0:

From the Tresca meter, $\overset{a}{R}{}^2_2 - A_0 = +1.5\mu$.

From meter C S [Rogers], $\overset{a}{R}{}^2_2 - A_0 = +1.1\mu$.

From meter C S [Benoit], $\overset{a}{R}{}^2_2 - A_0 = +2.3\mu$.

(*b*) In the reduction of the comparisons of the yard $\overset{a}{R}{}^2_2$ with "Bronze 11," the relation

"Bronze 11" + .000088 inch = Imperial Yard,

as determined by Hilgard and Chaney, was employed. From the Report of the Standard Department for 1883, it appears that Pierce found the relation,

"Bronze 11" + .000022 inch = Imperial Yard.

Substituting the latter relation for the former, I find:

From mean of observations by Mr. Edwin Smith and myself,

$$\overset{a}{R}{}^2_2 - 0.2\mu = \text{Imperial Yard.}$$

From the relation between C S and the Imperial Yard given by Mr. Chaney,

$$\overset{a}{R}{}^2_2 - 0.9\mu = \text{Imperial Yard.}$$

For the present the following relations will be adopted:

For the Meter.	For the Yard.
$\overset{a}{R}{}^2_2 - 1.6\mu = A_0$.	$\overset{a}{R}{}^2_2 - 0.6\mu = Y$.
$\overset{a}{R}{}^2_1 + 2.3\mu = A_0$.	$\overset{a}{R}{}^2_1 - 2.2\mu = Y$.

In the determination of the absolute length of $\overset{a,b,c}{S_0}$, $\overset{a}{S_1}$ and $\overset{a}{S_2}$, it was considered advisable to make the comparisons not only with the subdivisions of the bronze meter, but also with those of a steel meter, for the purpose of obtaining an independent check upon the work. In January, 1884, the writer constructed three meters upon bars of Jessup's steel, of the form described on p. 290 of the paper referred to above. Yard and Meter B was made for Professor Brockett of Princeton College; Yard and Meter A_4 was sent to

Professor Rowland, while Yard and Meter R_3 was retained for my own use.

Much attention has been given to the determination of the relation between the length of these three standards in terms of bronze R_2, especially with reference to the constancy of the equation. The equation between the Brockett Standard B and R_3 from observations in 1883, was found to differ by a sensible amount from the relation found in 1884. Again, the relation between R_2 and R_3, determined in the early part of 1884, differed materially from that found in the latter part of the same year. In order to obtain an additional test with regard to the constancy of a determined relation between these three standards, Professor Rowland kindly returned to me Yard and Meter A_4, in order that I might be able to repeat the comparisons with R_2, made in 1884. It does not seem advisable to burden this paper with the mass of details involved in these comparisons. In order, however, that the data may be furnished for the computation of the probable errors of observation, the separate results of the comparisons of R_2 with A_4 are given. They are as follows:

Results of the various determinations of the relative coefficient of expansion between bars R_1, R_2, R_3 *and* A_4.

Relative Coefficient Between
R_2 and R_3.

Limiting Times of Observations.	Weights.	Coefficient.	
1884. Feb. 5, to Mar. 5,	1	6.90μ	from meter.
" " " "	1	6.91	from yard.
" Nov. 16 to Dec. 21,	½	6.79	from meter.
" Dec. 21 to Dec. 31,	½	6.99	from meter.
1885. Jan. 20 to Feb. 15,	2	6.93	from meter.
" Feb. 16 to Mar. 5,	½	7.01	from meter.
" " " "	½	6.87	from yard.
		Mean=6.92μ	

Relative Coefficient Between
R_1 and R_3.

Limiting Times of Observations.	Weights.	Coefficient.	
1884. Feb. 5 to Mar. 5,	1	0.28μ	from meter.
" " " "	1	0.19	from yard.
" " " "	1	0.17	from meter.
" " " "	1	0.18	from yard.
		Mean=0.20μ.	

Coeff. of R_2=17.17μ. Coeff. of R_1=10.11μ.

Hence, Coeff. of R_3=10.25μ. Coeff. of R_3=10.31μ.

Relative Coefficient Between
R_2 and A_4.

Limiting Times of Observations.	Weights.	Coefficient.	
1884. Feb. 5 to Mar. 5,	1	6.90μ	from meter.
" " " "	1	6.91	from yard.
1885. Jan. 20 to Feb. 15,	1	6.93	from meter.
" Feb. 16 to Mar. 5,	$\frac{1}{2}$	7.01	from meter.
" " " "	$\frac{1}{2}$	6.88	from yard.
		Mean=6.93μ.	

Relative Coefficient Between
R_1 and A_4.

Limiting Times of Observations.	Weights.	Coefficient.	
1884. Feb. 5 to Mar. 5,	1	0.22μ	from meter.
" " " "	1	+0.19	from yard.
" " " "	1	+0.17	from meter.
" " " "	1	+0.18	from yard.
		Mean=0.19μ.	

Coeff. of R_2=17.17μ. Coeff. of R_1=10.11μ.

Coeff. of A_4=10.24μ. Coeff. of A_4=10.30μ.

By combination we have:

Absolute coefficient of R_3	$=10.25\mu$.	Weight 1	From R_2 and R_3
" " "	$=10.24\mu$	" 1	From R_2 and A_4
" " "	$=10.31\mu$	" $\frac{1}{2}$	From R_1 and R_3
" " "	$=10.30\mu$	" $\frac{1}{2}$	From R_1 and A_4

Whence, for the absolute coefficient of Jessup's steel for each degree centigrade we have:

$$10.265\mu.$$

For the relation between R_2 and R_3 the value 6.91μ has been adopted in the reductions which follow.

COMPARISON OF METERS.

From observations between Feb'y 5 and March 11, 1884.			From single observations between March 12 and March 21, 1884.		
No. obs.	Y 61*	R_2—A_4	Date.	Y 61.	R_2—A_4.
	°	At 16.67° C.		°	At 16.67° C.
3	+30.55	$+4.1\mu$	Mar. 12	+15.39	$+3.8\mu$
2	+27.48	+1.7	" 14	15.97	+4.9
4	+24.01	+4.4	" 15	14.32	+2.7
4	+14.16	+0.2	" 16	11.74	—0.1
2	+ 5.92	+5.3	" 17	10.87	+1.7
6	+ 2.40	+1.8	" 18	12.31	+3.2
5	+ 1.85	+3.0	" 19	12.62	+4.9
4	—3.24	+1.8	" 20	13.63	+5.5
3	—4.99	+2.5	" 20	11.98	+2.9
3	—7.91	+3.7	" 21	11.88	—0.5

* The readings of the thermometers Yale College, Y 61, and Baudin 8614, have been reduced to the standard adopted at the Thermometric Bureau of the Observatory of Yale College.

From Observations
Between January 20 and February 15, 1885.

Date.	Baudin 8614* °	$R_2 - A_4$. At 16.67° C.	Date.	Baudin 8614 °	$R_2 - A_4$. At 16.67° C.
Jan. 20	15.96	—2.0μ	Feb. 7	30.08	+ 1.6μ
" 20	15.17	+2.1	" 8	29.38	+0.8
" 30	13.70	—0.2	" 8	29.80	—1.3
" 30	15.90	—3.8	" 12	28.30	—1.8
" 30	17.52	+0.8	" 13	27.55	—0.2
" 20	16.54	—1.6	" 13	28.64	+2.4
" 28	18.34	+2.0	" 13	28.54	+2.6
" 20	26.54	+0.2	" 13	28.40	—1.2
" 21	27.21	—0.1	" 14	27.74	+4.1
" 28	26.19	+0.7	" 15	27.14	—2.0
" 28	29.43	+2.2	" 15	27.84	+4.2
" 28	28.78	—1.7	" 15	28.80	+4.7
" 28	28.34	+2.4	" 15	29.84	+0.0
" 20	28.93	—1.1	Jan. 21	41.91	+1.1
" 27	31.98	—1.1	" 21	40.13	—1.7
			" 21	41.25	—2.0
			Feb. 1	47.79	+3.1
			" 1	47.77	+1.5
			Jan. 25	78.65	—1.5
			" 26	80.14	+2.7
			" 26	81.42	+2.8
			" 25	81.82	—0.2
			" 26	81.76	+3.0

*The readings of the thermometers Yale College, Y 61, and Baudin 8614, have been reduced to the standard adopted at the Thermometric Bureau of the Observatory of Yale College.

COMPARISON OF YARDS.

From observations between Feb'y 5 and March 11, 1884.

No. obs.	Y 61.	$R^2_2—A_4$. At 16.67° C.
	°	
4	+30.56	+ 0.7μ
7	+25.80	+ 7.3
7	+24.53	+ 5.4
2	+14.89	+12.8
5	+ 5.88	+ 0.2
3	+ 4.45	+ 3.0
3	— 0.23	+ 6.2
6	— 6.42	+ 1.2
4	— 7.55	— 0.7
5	— 7.89	+ 0.2

From observations between March 12 and March 27, 1884.

Date.	Y 61.	$R^2_2—A_4$. At 16.67° C.
	°	
Mar. 12	15.39	+3.7μ
" 14	15.97	+0.4
" 15	14.32	—0.8
" 16	11.74	+4.5
" 17	10.89	—0.7
" 18	12.31	—2.4
" 19	12.62	+0.8
" 20	13.63	+0.5
" 20	11.98	+6.7
" 21	11.88	—4.9
" 23	14.48	—0.9
" 24	21.22	+1.1
" 25	10.88	—2.7
" 25	12.83	—2.9
" 26	14.56	+5.0
" 26	14.90	+7.4
" 14	14.96	+1.1
" 27	15.03	+0.4

From Observations

Between January 12 and February 24, 1885.

Date.	Baudin 8614.	$R^2_2—A_4$	Date.	Baudin 8614.	$R^2_2—A_4$	Date.	Baudin 8614.	$R^2_2—A_4$
	°			°			°	
Jan. 12	53.69	+6.4μ	Feb. 17	30.30	+6.8μ	Feb. 20	27.84	+5.6μ
" 12	57.81	+2.5	" 17	29.89	+4.7	" 21	27.56	+5.1
" 13	57.04	+2.3	" 17	29.80	—0.5	" 21	26.42	+1.9
" 14	51.22	—2.4	" 17	29.06	+5.7	" 21	27.88	—1.6
" 14	51.48	—3.6	" 18	27.54	+3.5	" 22	27.70	—1.5
" 14	53.87	—0.3	" 18	27.40	+2.2	" 23	27.72	—0.2
Feb. 16	29.54	+5.7	" 19	26.84	+0.6	" 24	27.36	+2.3
" 16	29.64	+5.3	" 20	27.46	+2.7			
" 16	30.16	+6.5						
" 16	30.98	+2.2						

Omitting the details of the comparisons of R_3 with $\dot{R}^2_2$ and R_1 we have for the mean results the following relations between $\dot{R}^2_2$, $\dot{R}^2_1$, R_3 and A_4. The Imperial Yard is designated by Y.

METERS.

Date of Comparisons.	Comparison with	Equations Between A_3 and A_0.	Weights.
1884, Feb. 5 to Mar 11.	R_2 (meter)	$R_3+4.0\mu=A_0$	1
" " " "	R_2 (yard)	$R_3+4.1\mu=A_0$	1
" " " "	R_1 (meter)	$R_3'+2.4\mu=A_0$	1
" " " "	R_1 (yard)	$R_3+2.7\mu=A_0$	1
" Nov. 16 to Dec. 21.	R_2	$R_3-1.2\mu=A_0$	½
" Dec. 21 to Dec. 31.	R_2	$R_3+2.2\mu=A_0$	2
1885, Jan. 2 to Feb. 15.	R_2	$R_3+1.9\mu=A_0$	3

Adopt. $\mathbf{R_3+2.4\mu=A_0}$.

YARDS.

1884, Feb. 5 to Mar. 11.	R_2 (yard)	$R_3+1.0\mu=Y$	1
" " " "	R_2 (meter)	$R_3-1.4\mu=Y$	1
" " " "	R_1 (yard)	$R_3-0.6\mu=Y$	1
" " " "	R_1 (meter)	$R_3-0.8\mu=Y$	1
1885, Jan. 12 to Feb. 16.	R_2	$R_3-0.5\mu=Y$	1

Adopt. $\mathbf{A_3-0.5\mu=Y}$.

METERS.

Date of Comparisons.	Comparison with	Equations Between A_4 and A_0.	Weights.
1884, Feb. 5 to Mar. 11.	R_2	$A_4+1.2\mu=A_0$	2
" Mar. 12 to Mar. 21.	R_2	$A_4+1.3\mu=A_0$	2
" Feb. 5 to Mar. 5.	R_1 (meter)	$A_4-0.4\mu=A_0$	1
" " " "	R_1 (yard)	$A_4-0.0\mu=A_0$	1
1885, Jan. 10 to Feb. 15.	R_2	$A_4-0.9\mu=A_0$	3

Adopt. $\mathbf{A_4+0.2\mu=A_0}$.

YARDS.

1884, Feb. 5 to Mar. 11.	R_2	$A_4+1.8\mu=Y$	2
" Mar. 12 to Mar. 27.	R_2	$A_4+1.3\mu=Y$	2
" Feb. 5 to Mar. 5.	R_1 (yard)	$A_4+1.4\mu=Y$	1
" " " "	R_1 (meter)	$A_4+0.2\mu=Y$	1
1885, Jan. 12 to Feb. 24.	R_2	$A_4+1.8\mu=Y$	3

Adopt. $\mathbf{A_4+1.1\mu=Y}$.

It may be said that the disagreement in the results given above, is not much greater than the probable error of observation, except in the case of the equation $R_3—1.2\mu=A_0$. Here, the agreement between the separate comparisons forbids the assumption of accidental errors as the cause of the variation. Besides, the disagreement between the different values of the relation $R_2—B$, omitted here on account of the incompleteness of the first set of observations, is even greater than for $R_2—R_3$.

In all of the comparisons made since 1884, especial pains have been taken to eliminate the error arising from the failure of the thermometer when placed upon the upper surface of the standards to indicate the real temperature of the metal. Even when a thermometer reading seems to be stationary, it has a *drift* up or down. The direction of this drift is always noted, and the aim has been to combine the observations in such a manner as to balance the errors due to this cause. Very gradually, however, the conviction has been forced upon me that when the temperature of a considerable mass of metal is obtained from the reading of a thermometer placed upon its surface, errors of long period are always introduced which escape detection in a short series of observations, but which manifest themselves in a long series in passing from winter to summer and *vice versa*. This view must at present be taken as a working hypothesis; but if it should prove to be correct, it will have an important bearing upon the work already done in metrology.

In order to test this theory it is absolutely necessary that the comparisons shall be made in a room in which an apparently steady temperature can be maintained for a long period of time, and in which the changes which occur are very slow. Otherwise, it would be impossible to separate the errors of short period from those of long period. Through an appropriation from the Rumford Committee of the American Academy of Arts and Sciences, a comparing room has been built beneath the rotunda of the Observatory which nearly fulfills the required conditions. The full account of the work undertaken by Mr. McRae and by the writer, under this appropriation, will appear in a report to the Academy, but by permission the results of the comparisons between R_2 and R_3 are given here. They are as follows:

Date.	T.	$R_2^2-R_3$	Date.	T.	$R_2^2-R_3$	Date.	T.	$R_2^2-R_3$
	°	At 16.67°c.		°	At 16.67°c.		°	At 16.67°c.
May 25	9.52	+6.6μ	Jan. 1	10.73	+5.1μ	Jan. 15	13.04	+4.0μ
" 25	9.32	+3.2	" 1	10.83	+3.2	" 15	13.37	+2.8
" 25	9.61	+2.2	" 1	10.89	+3.6	" 16	13.30	+3.7
" 25	9.77	+5.3	" 1	10.80	+5.7	" 16	13.30	+3.6
" 25	10.03	+7.0	" 2	10.67	+5.2	" 21	15.17	+4.1
" 26	10.13	+5.2	" 2	18.84	+6.5	" 22	15.12	+1.7
" 26	10.15	+4 8	" 3	10.71	+4.0	" 23	13.95	+3.2
" 27	10.17	+6.1	" 3	10.79	+5.5	" 23	13.95	+3.5
" 27	10.20	+4.8	" 3	10.96	+3.2	" 24	13.97	+1.6
" 27	10.68	+7.1	" 3	11.14	+2.9	" 25	13.98	+1.8
" 28	10.84	+6.2	" 3	11.33	+4.4	" 26	14.68	—0.5
" 28	10.59	+4.9	" 3	11.38	+3.7	" 27	15.73	+1.2
" 28	11.47	+3.2	" 4	11.00	+3.6	" 27	15.68	+2.1
" 28	11.70	+5.5	" 4	11.33	+4.4	" 28	15.75	+1.1
" 28	11.82	+5.6	" 4	11.55	+2.9	" 28	15.46	—1.0
" 29	9.96	+3.7	" 4	11.68	+5.4	July 1	14.73	+4.1
" 29	10.47	+2.7	" 5	11.22	+3.9	" 2	14.62	+5.4
" 29	12.14	+3.6	" 8	12.12	+5.8	" 3	14.80	+3.5
" 29	10.80	+1.2	" 9	11.75	+4.9	" 4	15.15	+1.9
" 31	10.76	+5.0	" 10	11.78	+4.2	" 5	15.10	+3.5
" 31	10.71	+5.3	" 11	11.78	+3.6	" 6	15.10	+1.0
" 31	10.88	+6.3	" 13	13.13	+3.6	" 7	15.14	+1.9
Jan. 1	10.56	+6.2	" 14	13.49	+4.0	" 8	15.14	+2.0

Arranging the results in groups of 10 each, we have—

From May 25 to May 27,	$R_2-R_3=+5.32\mu$
" May 28 to May 31,	+4.16
" May 31 to June 2,	+4.81
" June 3 to June 4,	+4.00
" June 5 to June 16,	+4.05
" June 16 to June 27,	+2.23
" June 28 to July 8,	+2.34

If these observations can be trusted, we have here a decided diminution in the value of the relation R_2-R_3, between May and July. It may be added, also, that the evidence of this diminution is still more marked in the comparisons of R_2 with the glass bar G, de-

scribed on page 295 of the Memoir above referred to. In this case the observations extend from March to July, 1885.

Adopting the mean of the values given above, we have—

$$R_3 + 3.8\mu = R_2 = A_0 + 1.6\mu$$

Or $$R_3 + 2.2\mu = A_0.$$

The relation previously obtained, is—

$$R_3 + 2.4\mu = A_0.$$

Until further comparisons have been obtained, the relation,

$$R_3 + 2.3\mu = A_0.$$

will be adopted.

Since R_2 has defining lines only for the meter and for the half meters, a new set of graduations was laid off upon the edge of this bar. The lines are ruled directly upon the bronze metal, and the sub-divisions are of the same form as upon R_3, with the exception of the last decimeter, which is subdivided to centimeters. This set of graduations is designated $\dot{R}_2$.

Comparison of Meter $\dot{R}_2$ with $\dot{R}^2_2$.

With old Comparator.

Date.	$\dot{R}^2_2 - \dot{R}_2$.
1884, July 19	$+5.9\mu$
" " 19	+5.3
" " 19	+5.1
1885, Mar. 16	+4.4
" " 16	+4.6
" " 16	+4.8
" " 17	+5.3
" " 17	+5.5
" " 18	+4.6
" " 22	+3.2
" " 24	+4.1
" " 24	+2.5
" " 25	+3.0
Mean,	4.49μ

With new Comparator.

Date.	$\dot{R}^2_2 - \dot{R}_2$.
1885, Apl. 1	$+3.8\mu$
" " 1	+4.7
" " 2	+3.4
" " 2	+4.8
" " 3	+3.7
" " 3	+3.8
Mean,	4.03μ

Adopt. $\dot{R}_2 + 4.3\mu = \dot{R}^2_2$

Whence:

$$\dot{R}_2 + 2.7\mu = A_0$$

The relation, $\dot{R}_2 - 0.5\mu = Y$, is also given, omitting details.

Sub-divisions of $\dot{R}_2$ and R_3 into Two Equal Parts.

$\frac{1}{2}$ Meters of $\dot{R}_2$.		$\frac{1}{2}$ Meters of R_3.	
Date.	I–II.	Date.	I–II.
1884, June 15	$+1.9\mu$	1884, Oct. 17	$+1.8\mu$
" June 27	$+2.4$	" " 28	-1.9
" July 15	$+2.2$	" " 30	$+0.1$
" July 18	$+1.5$	" " 30	$+2.5$
" Oct. 14	$+2.2$	1885, Jan. 15	$+2.3$
" Oct. 15	$+1.5$	" " 16	-1.8
" Oct. 17	$+1.7$	" " 16	-1.0
" Oct. 17	$+2.6$	" " 19	-1.4
		" " 20	-2.0
		" " 22	-2.2
		" " 22	-1.8
		" " 22	$+1.8$

Whence:

$$\mathrm{I} - 1.0\mu = \tfrac{1}{2}\dot{R}_2. \qquad \mathrm{I} + 0.15\mu = \tfrac{1}{2}R_3.$$

$$= \tfrac{1}{2}A_0 - 1.3\mu \qquad = \tfrac{1}{2}A_0 - 1.15\mu$$

And $\mathrm{I} + 0.3\mu = \frac{1}{2}A_0$ And $\mathrm{I} + 1.3\mu = \frac{1}{2}A_0$.

Hence, that half of the meter which is sub-divided to decimeters is, in the case of $\dot{R}_2$, 0.3μ *too short*, and in the case of R_3 is 1.3μ *too short*, compared with one-half of the Metre des Archives.

Relative corrections of the decimeter sub-divisions. Separate results of observations made between Feb. 17 and Feb. 23, 1885:

DECIMETERS OF R_3.

1	2	3	4	5
—3.5μ	—2.9μ	+6.4μ	—2.4μ	+2.4μ
—5.0	—2.1	+6.8	—1.8	+2.1
—4.5	—2.6	+7.5	—2.9	+2.4
—5.1	—2.4	+6.0	—2.9	+3.4
—4.5	—2.7	+7.1	—2.5	+2.3
—5.9	—1.5	+7.4	—2.3	+3.1
—5.1	—1.4	+6.1	—0.2	+0.7
—5.3	—1.4	+5.6	—0.9	+2.0
—4.0	—3.2	+6.5	—3.0	+3.6
—5.2	—1.6	+6.9	—2.5	+2.4
—5.4	—2.2	+5.5	—1.2	+3.2
—6.4	—3.0	+6.6	—0.7	+3.5
—5.8	—3.3	+7.6	—1.4	+3.2
—5.3	—2.6	+6.6	—1.4	+2.8
—5.2	—2.6	+7.2	—1.3	+1.8
—6.6	—3.1	+7.3	—0.6	+3.0
—6.3	—3.4	+6.6	—0.6	+3.7
—4.4	—1.8	+6.9	—2.4	+1.7

DECIMETERS OF R_2.

—0.6μ	+3.2μ	+1.7μ	—0.6μ	—3.6μ
+1.5	+2.8	+0.8	—1.2	—3.8
+1.1	+2.4	+0.1	—2.1	—1.4
+1.2	+1.6	+0.8	—0.3	—3.4
+1.7	+2.3	+2.4	—1.4	—4.9
+1.3	+2.8	+1.6	—1.8	—3.8
+1.0	+2.9	+1.9	—2.2	—3.6
—0.1	+2.1	+2.7	—0.6	—4.3
+0.9	+1.7	+2.3	—0.3	—4.7

Taking the means, we have—

	Corrections to dms. of R_3.	Σ	Corrections to dms. of $\dot{R}_2$.	Σ
*1	-5.17μ	-5.17μ	$+0.89\mu$	$+0.89\mu$
2	-2.43	-7.60	$+2.42$	$+3.31$
3	$+6.70$	-0.90	$+1.59$	$+4.90$
4	$+1.72$	-2.62	-1.17	$+3.73$
5	$+2.63$	$+0.00$	$+3.73$	$+0.00$

The relative corrections for the separate centimeters are given without details, as follows:

	Centimeters of R_3.	Σ
1	-5.6μ	-5.6μ
2	$+3.8$	-1.8
3	-1.7	-3.5
4	$+5.2$	$+1.7$
5	-1.7	$+0.0$

	Centimeters of $\dot{R}_2$.	Σ
1	-3.4μ	-3.4μ
2	$+1.9$	-1.5
3	$+0.6$	-0.9
4	-1.1	-2.0
5	-0.4	-2.4
6	$+0.1$	-2.3
7	-0.6	-2.9
8	$+0.0$	-2.9
9	$+0.4$	-2.5
10	$+2.5$	$+0.0$

	5 Centimeter Spaces of R_3.	Σ
1	$+5.6\mu$	$+5.6\mu$
2	-5.6	0.0

Since the first 15 centimeters of S_0^{abc} will be compared with the first 15 centimeters of R_3, it is necessary to obtain the total amount of the correction for this space. We have—

The second decimeter is relatively too long,	-2.43μ
The second 5 centimeter space of the first decimeter is too long, ...	-5.60μ
One-half of the first decimeter is too long	-2.58μ
The 15 centimeter space is too short, on account of the relation $I+1.3\mu=\frac{1}{2}A_0$	$+0.39\mu=\frac{3}{10}\times 1.3\mu$

* The decimeter at the end of the bar. A plus sign indicates that the measured space is shorter than the mean—a minus sign that it is longer than the mean.

Hence:

The first 15 centimeters of R_3—$10.2\mu = \frac{15}{100} A_0$.

In the same way it will be found that—

The first decimeter of $\dot{R}_2$	**$+1.0\mu = \frac{1}{10} A_0$.**
The first two decimeters of $\dot{R}_2$	**$+3.4\mu = \frac{1}{5} A_0$.**
The first decimeter of R_3	**$-4.9\mu = \frac{1}{10} A_0$.**
The first two decimeters of R_3	**$-7.1\mu = \frac{1}{5} A_0$.**

We must now determine the coefficient of expansion of the speculum metal with all possible precision.

Seven separate series of observations were undertaken for this purpose. They are described as follows:

Series (a) consists of the comparison of a half meter and a half yard $\overset{a}{S_0}$ with the screw W of my dividing engine, which has the coefficient 10.60μ. The bar was supported upon the platen at its neutral points, and was adjusted for level and for line of motion by means of a microscope attached to a carriage which has an independent movement parallel with the screw. The comparisons were made by running the screw carriage to one end, adjusting the micrometer of the microscope for coincidence with the initial line of the standard, and then by carrying the bar forward by means of the screw until the coincidence of the terminal line with the micrometer line of the stationary microscope was made. The difference between the readings for the two positions at one temperature compared with the difference at another temperature, together with the difference of the temperatures, are the data from which the relative coefficient was obtained.

Series (b) consists of a set of comparisons of a half yard and a half meter S made for Professor C. K. Wead of the University of Michigan with standards R_2 and R_3.

Series (c). In this series, half yard and half meter $\overset{a}{S_0}$ were compared with R_3, before June, 1884.

Series (d). Half yard and half meter $\overset{b}{S_0}$ compared with R_2 before before June, 1884.

Series (e). Half yard and half meter $\overset{b}{S}_0$, compared with R_2 between July and November, 1884.

Series (f). Half yard and half meter $\overset{b}{S}_0$ compared with R_3 between July and November, 1884.

Series (g). In this series the comparison of R_3 was made with half meters $\overset{a}{S}_0$, $\overset{b}{S}_0$, $\overset{c}{S}_0$, and also with the other sets of graduations $\overset{d}{S}_0$, $\overset{e}{S}_0$, $\overset{f}{S}_0$, in which the lines are quite heavy. The observations extend from December 12, 1884, to January 23, 1885. In this series a Fahrenheit thermometer was employed, but the readings are reduced to the Yale standard.

The comparisons are all given in the form of equations, each equation representing the mean of all the observations made near the temperature indicated by the coefficient of the unknown quantity (b). The separate values of the quantity (a), which represents the difference in length between the standards compared at 62.00 Fahr., are also given, as well as the residuals (v) from the mean value.

SERIES (a).

EQUATIONS OF CONDITION.

½ Meter S_0 with W.

No. Obs.	$W-S_1$.		$(16.\overset{\circ}{6}7$ F.)	Residuals. a	v
3	-25.5μ	=	$a+4.02b$	-10.7μ	$+2.7\mu$
5	-27.6	=	$a+3.45$	-14.9	-1.5
4	-21.0	=	$a+2.24$	-12.8	$+0.6$
5	-20.9	=	$a+1.19$	-16.5	-3.1
4	-9.4	=	$a+0.14$	-8.9	$+4.5$
4	-10.3	=	$a-0.93$	-13.7	-0.3
5	-7.7	=	$a-1.84$	-14.5	-1.1
3	$+0.1$	=	$a-4.03$	-14.7	-1.3
4	$+5.6$	=	$a-4.83$	-12.1	$+1.3$
5	$+7.5$	=	$a-6.05$	-14.8	-1.4

Normal Equations.

$$-109.2\mu = 10a - 6.64b$$

$$-320.0\mu = -6.64a + 114.94b.$$

$$b = -3.55\mu.$$

$$b = -3.81\mu \text{ from } \tfrac{1}{2} \text{ yard.}$$

Coeff. of $W = 10.60\mu$.

Coeff. between W and $S_0 = 3.68\mu$.

Coeff. of $S_0 = 17.96\mu$.

EQUATIONS OF CONDITION.

½ Yard S_0 with W.

No. Obs.	$W - S_0$	$(16.67^{\circ}$ F.)	Residuals. a	Residuals. v
4	-25.3μ	$= a + 4.02b$	-11.7μ	$+0.6\mu$
4	-26.1	$= a + 3.45$	-14.4	-2.1
3	-22.6	$= a + 2.13$	-15.4	-3.1
4	-20.1	$= a + 1.22$	-16.0	-3.7
5	-8.1	$= a + 0.03$	-8.0	$+4.3$
4	-5.9	$= a - 0.73$	-8.4	$+3.9$
3	-3.0	$= a - 1.71$	-8.8	$+3.5$
4	-0.7	$= a - 4.08$	-14.5	-2.2
4	$+2.3$	$= a - 4.74$	-13.7	-1.4
5	$+8.4$	$= a - 6.05$	-12.0	$+0.3$

Normal Equations.

$$-101.1\mu = -10a - 6.46b.$$

$$-314.1\mu = -6.46a + 113.26b.$$

$$b = 3.48\mu.$$

$$b = 3.81\mu \text{ for } \tfrac{1}{2} \text{ meter.}$$

SERIES (b).

½ Meter S with ½ R_2.

No. Obs.	$\frac{1}{2} R_2 - S$.	$(16.67^{\circ}$ F.)	Residuals. a	Residuals. v
6	$+14.0\mu$	$= a + 6.92b$	$+11.0\mu$	-0.3μ
6	$+11.9$	$= a + 1.40$	$+11.3$	$+0.0$
6	$+10.3$	$= a - 0.41$	$+10.5$	-0.8
6	$+11.3$	$= a - 3.84$	$+12.9$	$+1.9$
6	$+4.9$	$= a - 13.34$	$+10.6$	-0.7

Normal Equations.

$$+52.40\mu = 5a - 9.27b.$$

$$+0.56\mu = -9.27a + 242.73b.$$

$$b = 0.43\mu.$$

Coeff. between R_2 and $S = 0.86\mu$ for 1 meter.

Coeff. of $R_2 = 17.17\mu$.

Coeff. of $S = 18.03\mu$.

½ Yard S with ½ R_3.

No. Obs.	½ R_3—S. (16.67 F.)	Residuals. a	v
6	$+33.0\mu = a + 6.63b$	$+10.0\mu$	-1.0μ
6	$+15.5 = a + 1.38$	$+10.7$	-0.3
6	$+7.1 = a + 0.16$	$+10.1$	-0.9
6	$+0.6 = a - 4.03$	$+14.6$	$+3.6$
6	$-43.5 = a - 15.34$	$+9.7$	-1.3

Normal Equations.

$$+12.70\mu = 5a - 12.22b.$$

$$+898.94\mu = -12.22a + 298.16b.$$

$$b = 3.47\mu.$$

$b = 3.79\mu$ for ½ meter.

Coeff. between R_3 and $S = 7.58\mu$.

Coeff. of $R_3 = 10.27\mu$.

Coeff. of $S = 17.85\mu$.

SERIES (c).

½ Meter $\overset{a}{S}_0$ with ½ R_3.

No. Obs.	½ R_3—$\overset{a}{S}_0$. (16.67 F.)	Residuals. a	v
4	$+40.6\mu = a + 8.87b$	$+6.9\mu$	-1.0μ
4	$+21.7 = a + 3.10$	$+9.9$	$+2.0$
5	$+14.2 = a + 2.14$	$+6.1$	-1.8
4	$+14.2 = a + 1.14$	$+9.9$	$+2.0$
3	$+8.0 = a + 0.13$	$+7.5$	-0.4
2	$+10.7 = a + 0.05$	$+10.5$	$+2.6$
3	$+4.0 = a - 1.11$	$+8.2$	$+0.3$
4	$-37.0 = a - 12.33$	$+9.9$	$+2.0$
5	$-54.7 = a - 15.09$	$+2.6$	-5.3
5	$-48.1 = a - 14.24$	$+9.8$	$+1.9$
6	$-56.2 = a - 16.58$	$+6.8$	-1.1
5	$-59.3 = a - 17.48$	$+7.1$	-0.8

Normal Equations.

$$-141.9\mu = 12a - 62.40b.$$
$$+4406.03\mu = -62.40a + 1287.87b.$$
$$b = +3.80\mu$$

Coeff. between R_3 and $\overset{a}{S}_0 = 7.60\mu$.

Coeff. of $R_3 = 10.27\mu$.

Coeff. of $\overset{a}{S}_0 = 17.87\mu$.

$\frac{1}{2}$ Yard $\overset{a}{S}_0$ with $\frac{1}{2}$ R_3.

No. Obs.	$\frac{1}{2}R_3 - \overset{a}{S}_0$.	(16.67 F.)	Residuals. a	v
4	$+38.2\mu$	$= a + 8.85b$	$+7.1\mu$	-3.9μ
4	$+38.8$	$= a + 8.79$	$+7.9$	-3.1
5	$+30.1$	$= a + 5.55$	$+10.6$	-0.3
4	$+24.8$	$= a + 3.10$	$+13.9$	$+3.0$
3	$+17.5$	$= a + 2.14$	$+12.0$	$+1.0$
3	$+20.3$	$= a + 2.14$	$+12.8$	$+1.8$
4	$+13.2$	$= a + 1.45$	$+8.1$	-2.9
4	$+16.8$	$= a + 1.14$	$+12.8$	$+1.8$
3	$+5.2$	$= a + 0.12$	$+4.8$	-6.2
3	$+13.3$	$= a + 0.05$	$+13.1$	$+2.1$
3	$+7.5$	$= a + 0.03$	$+7.4$	-3.6
4	$+8.7$	$= a - 0.43$	$+10.2$	-0.8
4	$+6.0$	$= a - 1.11$	$+9.9$	-1.1
5	$+2.1$	$= a - 2.91$	$+12.3$	$+1.3$
6	$+2.9$	$= a - 3.51$	$+15.3$	$+4.3$
4	$+2.9$	$= a - 3.51$	$+15.3$	$+4.3$
2	$+0.0$	$= a - 4.29$	$+15.1$	$+4.1$
3	$+0.4$	$= a - 4.33$	$+15.6$	$+4.6$
4	-3.1	$= a - 4.53$	$+12.8$	$+1.8$
5	-34.6	$= a - 12.33$	$+8.8$	-2.2
6	-42.4	$= a - 15.09$	$+10.7$	-0.3
5	-41.1	$= a - 15.24$	$+12.5$	$+1.5$
4	-48.2	$= a - 16.58$	$+10.2$	-0.8
3	-57.4	$= a - 17.48$	$+4.1$	-7.2

Normal Equations.

$$+2.19\mu = 24a - 67.98b.$$
$$+4524.3\mu = -67.98a + 1493.20b.$$
$$b = 3.52\mu.$$
$$b = 3.85\mu \text{ for } \tfrac{1}{2} \text{ meter.}$$

Coeff. between R_3 and $\overset{a}{S}_0 = 7.70\mu$.

Coeff. of $R_3 = 10.27\mu$.

Coeff. of $S_0 = 17.97\mu$.

SERIES (d).

$\frac{1}{2}$ Meter $\overset{b}{S}_0$ with $\frac{1}{2}$ R_2.

No. Obs.	$\frac{1}{2}R_2 - \overset{b}{S}_0$. (16.67 F.)	Residuals. a	v
3	$+12.2\mu = a + 8.79b$	$+9.0\mu$	$+1.1\mu$
4	$+8.4 = a + 3.10$	$+7.3$	-0.6
5	$+7.2 = a + 2.10$	$+6.4$	-1.5
4	$+10.0 = a + 1.45$	$+9.5$	$+1.6$
3	$+10.2 = a + 1.14$	$+9.8$	$+1.9$
4	$+9.4 = a + 0.13$	$+9.4$	$+1.5$
3	$+6.6 = a + 0.07$	$+6.6$	-1.3
4	$+8.0 = a - 0.75$	$+8.3$	$+0.4$
3	$+9.2 = a - 1.11$	$+9.6$	$+1.7$
3	$+3.1 = a - 12.33$	$+7.5$	-0.4
4	$+1.2 = a - 15.09$	$+6.6$	-1.3
5	$+0.7 = a - 15.24$	$+6.2$	-1.7
4	$-1.1 = a - 16.58$	$+4.9$	-3.0
4	$+2.7 = a - 17.48$	$+9.0$	$+1.1$

Normal Equations.

$$+87.8\mu = 14a - 61.80b.$$
$$+64.04\mu = 61.80a + 1288.94b.$$
$$b = +0.32\mu.$$

Coeff. of $R_2 = 17.17\mu$.

Coeff. between R_2 and $\overset{b}{S}_0 = 0.64\mu$.

Coeff. of $\overset{b}{S}_0 = 17.81\mu$.

$\frac{1}{2}$ Yard $\overset{b}{S_0}$ with $\frac{1}{2}$ R_2.

No. Obs.	$R_2 - \overset{b}{S_0}$. (16.67 F.)		Residuals. a	v
3	$+13.4\mu =$	$a + 8.87b$	$+10.5\mu$	-0.7μ
4	$+12.8 =$	$a + 8.79$	$+9.9$	-1.3
5	$+15.7 =$	$a + 3.10$	$+14.7$	$+3.5$
5	$+12.6 =$	$a + 2.14$	$+11.9$	$+0.7$
5	$+12.8 =$	$a + 2.14$	$+12.1$	$+0.9$
4	$+13.2 =$	$a + 1.45$	$+12.7$	$+1.5$
5	$+13.4 =$	$a + 1.14$	$+13.0$	$+1.8$
4	$+7.5 =$	$a + 0.13$	$+7.5$	-3.7
5	$+8.8 =$	$a + 0.12$	$+8.5$	-2.7
4	$+9.7 =$	$a + 0.15$	$+9.7$	-1.5
5	$+9.1 =$	$a - 0.43$	$+9.2$	-2.0
5	$+11.7 =$	$a - 0.75$	$+11.9$	$+0.7$
5	$+12.3 =$	$a - 1.11$	$+12.7$	$+1.5$
4	$+11.8 =$	$a - 2.91$	$+12.8$	$+1.6$
4	$+10.9 =$	$a - 3.51$	$+12.1$	$+0.9$
4	$+12.6 =$	$a - 3.51$	$+13.8$	$+2.6$
5	$+11.5 =$	$a - 4.23$	$+12.9$	$+1.7$
4	$+11.6 =$	$a - 4.33$	$+13.0$	$+1.8$
4	$+9.3 =$	$a - 4.53$	$+10.8$	-0.4
4	$+2.2 =$	$a - 12.33$	$+6.3$	-4.9
5	$+5.0 =$	$a - 15.79$	$+10.0$	-1.2
4	$+6.3 =$	$a - 15.24$	$+11.3$	$+0.1$
3	$+6.4 =$	$a - 16.58$	$+11.9$	$+0.7$
4	$+4.6 =$	$a - 17.48$	$+10.4$	-0.8

Normal Equations.

$$+24.49\mu = 24a - 74.00b.$$
$$-297.02\mu = -74.00a + 1462.85b.\mu$$
$$b = 0.37\mu \text{ for } \tfrac{1}{2} \text{ yard.}$$
$$b = 0.40\mu \text{ for } \tfrac{1}{2} \text{ meter.}$$

Coeff. of $R_2 = 17.17\mu$.

Coeff. between R_2 and $\overset{b}{S_0} = 0.80\mu$.

Coeff. of $\overset{b}{S_0} = 17.97$.

SERIES (e).

$\frac{1}{2}$ Meter and $\frac{1}{2}$ Yard $\overset{b}{S}_0$ with $\frac{1}{2}$ R_2.

$\frac{1}{2}$ Meter.

No. Obs.	$R_2 - \overset{b}{S}_0$.	(16.67 F.)	Residuals. a	v
5	+18.6div.	= a+10.95b	5.8μ	—1.6μ
8	+15.8	= a— 1.65	9.0	+1.6
9	+16.2	= a— 3.44	9.9	+2.5
7	+ 3.0	= a— 9.57	5.3	—2.1
4	+ 1.6	= a—16.15	6.9	—0.5

Normal Equations.

+55.40 div.=5a—19.86b.

+65.41 div.= —19.86a+486.85b.

b= —0.70 div.

b= —0.35μ.

Coeff. R_2=17.17μ.

Coeff. between R_2 and $\overset{b}{S}_0$=0.70μ.

Coeff. $\overset{b}{S}_0$=17.87μ.

$\frac{1}{2}$ Yard.

No. Obs.	$R_2 - \overset{b}{S}_0$.	(16.67 F.)	Residuals. a	v
5	+17.0	= a+10.95b	+5.0μ	—1.8μ
8	+13.1	= a— 1.65	+8.2	+1.4
9	+14.8	= a— 3.44	+9.1	+2.2
7	+ 6.8	= a— 9.57	+7.1	+0.3
4	— 2.2	= a—16.15	+4.8	—2.0

Normal Equations.

+49.5 div.=5a—19.86b.

+84.1 div.= —19.86a+486.85b.

b= —0.69 div.

b=0.35μ for $\frac{1}{2}$ yard.

b=0.28μ for $\frac{1}{2}$ meter.

Coeff. R_2=17.17μ.

Coeff. between R_2 and $\overset{b}{S}_0$= .76μ.

Coeff. S_0=17.93μ.

SERIES (f).

$\frac{1}{2}$ Meter and $\frac{1}{2}$ Yard $\overset{b}{S}_0$ with $\frac{1}{2}$ R_3.

$\frac{1}{2}$ Meter.

No. Obs.	$\frac{1}{2} R_3 - \overset{b}{S}_0$.	(16.67 F.)	Residuals. a	v
6	+ 97.7div.	=a+10.95b	+7.5μ	+0.0μ
6	+ 38.2	=a+ 3.49	+6.2	—1.3
6	— 9.5	=a— 3.48	+8.9	+1.4
6	— 72.2	=a—11.09	+6.3	—1.3
6	—116.8	=a—17.35	+8.8	+1.3

Normal Equations.

$$-62.6 \text{ div.} = 5a - 17.48b,$$

$$+4063.4 \text{ div.} = -17.48a + 568.20b.$$

$$b = 7.58 \text{ div.}$$

$$b = 3.81\mu.$$

$$\text{Coeff. of } R_3 = 10.27\mu.$$

$$\text{Coeff. between } R_3 \text{ and } \overset{b}{S}_0 = 7.62\mu.$$

$$\text{Coeff. of } \overset{b}{S}_0 = 17.89\mu.$$

$\frac{1}{2}$ Yard.

No. Obs.	$\frac{1}{2} R_3 - \overset{b}{S}_0$.	(16.67 F.)	Residuals. a	v
6	+ 89.2div.	=a+10.95b	+5.7μ	—1.0μ
6	+ 38.6	=a+ 3.49	+7.2	+0.5
6	— 10.6	=a— 3.48	+7.5	+0.8
6	— 65.6	=a—11.09	+7.4	+0.7
6'	—113.1	=a—17.35	+5.8	—0.9

Normal Equations.

$$-61.5 \text{ div.} = 5a - 17.48b.$$

$$+383.81 \text{ div.} = -17.48b + 568.2b.$$

$$b = 7.15 \text{ div.} = 3.60\mu.$$

$$b = 3.94\mu \text{ for } \tfrac{1}{2} \text{ meter.}$$

$$\text{Coeff. of } R_3 = 10.27\mu.$$

$$\text{Coeff. between } R_3 \text{ and } \overset{b}{S}_0 = 7.88\mu.$$

$$\text{Coeff. } \overset{b}{S}_0 = 18.15\mu.$$

SERIES (g).

$\frac{1}{2}$ Meter $\overset{abcdef}{S_0}$ with $\frac{1}{2}$ R_s [in divisions of micrometer.]

No. Obs.	$\frac{1}{2}R_s-\overset{a}{S_0}$	$\frac{1}{2}R_s-\overset{b}{S_0}$	$\frac{1}{2}R_s-\overset{c}{S_0}$	$\frac{1}{2}R_s-\overset{d}{S_0}$	$\frac{1}{2}R_s-\overset{e}{S_0}$	$\frac{1}{2}R_s-\overset{f}{S_0}$	
4	+183.3	+186.6	+205.7	+215.7	+188.3	+190.2	= a+47.59b
4	+166.4	+173.0	+192.4	+205.5	+167.9	+176.7	= a+43.21b
4	+133.7	+138.7	+158.2	+169.8	+137.3	+138.3	= a+34.37b
4	+ 91.4	+ 96.1	+116.8	+127.2	+ 90.1	+ 88.8	= a+24.20b
4	+ 24.4	+ 28.7	+ 48.4	+ 58.7	+ 24.5	+ 33.0	= a+ 7.87b
4	— 95.2	— 98.0	— 79.2	— 70.2	— 99.1	— 94.1	= a—19.23b

Equations of Condition.

From $R_s-\overset{a}{S_0}$.

+84.00=a+23.00b.
—179.28=a+45.87b.
a=—11.9 div.
b=+4.17 div.

From $R_s-\overset{b}{S_0}$.

87.52=a+23.00b.
185.19=a+45.87b.
a=—10.3 div.
b=+4.27 div.

From $R_s-\overset{c}{S_0}$.

+107.05=a+23.00b.
204.85=a+45.87b.
a=+9.00.
b=+4.28.

From $R_s-\overset{d}{S_0}$.

+117.78=a+23.00b.
+216.44=a+45.87b.
a=+18.6.
b=+4.31.

From R_s and $\overset{c}{S_0}$.

+84.83=a+23.00b.
+182.70=a+45.87b.
a=—13.6.
b=+4.28.

From $R_s-\overset{b}{S_0}$.

+88.82=a+23.00b.
+185.92=a+45.87b.
a=—8.9.
b=+4.25.

Collecting the results of this series we have:

		For 1 Meter.	Equivalent for 1° C.	Coeff. S_0
Coeff. between $\frac{1}{2}$ R_3 and	$\overset{a}{S_0}$ = 2.10μ =	4.20μ =	7.56μ	17.83μ
" " "	$\overset{b}{S_0}$ = 2.15 =	4.30 =	7.74	18.00
" " "	$\overset{c}{S_0}$ = 2.16 =	4.32 =	7 78	18.04
" " "	$\overset{d}{S_0}$ = 2.17 =	4.33 =	7.81	18.08
" " "	$\overset{e}{S_0}$ = 2.16 =	4.32 =	7.78	18.04
" " "	$\overset{f}{S_0}$ = 2.14 =	4.28 =	7.70	17.97
			Mean	17.99

Combining the results of each series we have:

Coefficient from Series (a) = 17.96μ
" " " (b) = 17.94μ
" " " (c) = 17.92μ
" " " (d) = 17.89μ
" " " (e) = 17.90μ
" " " (f) = 18.02μ
" " " (g) = 17.99μ

We have, therefore, finally, for the coefficient of the speculum metal made by Professor Rowland—

17.946μ.

The next step in the operation of standardizing the speculum scales $\overset{s}{S}_0$, $\overset{s}{S}_1$ and $\overset{s}{S}_2$, was their comparison with the correspond-

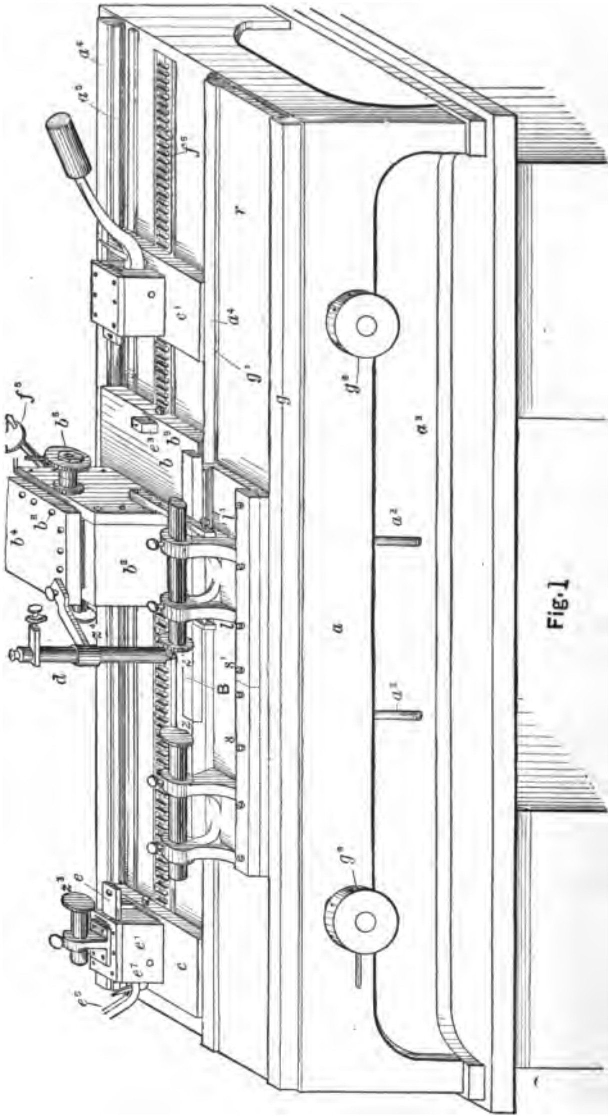


Fig. 1

ing units of R_2 and R_3. In order to secure as great a degree of independence as possible in these comparisons, the conditions under

which they were made were varied by the use of comparators of different forms of construction, which were mounted in different locations, and also by the interchange of the thermometers employed. The old comparator, of which a description is given in my paper, "On Two Forms of Comparators for Measures of Length," is mounted in the new comparing-room beneath the rotunda of the Observatory. The comparator, constructed by the writer in the latter part of 1884, is mounted in the comparing-room situated in the west cellar of the Observatory.

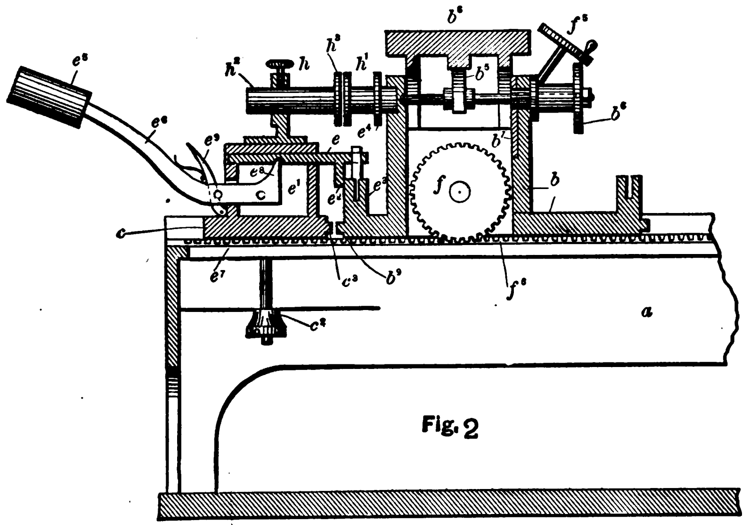


Fig. 2

The main features of this instrument will be seen from the following outline references. In Fig. 1, the microscope slide b^2, which is closely fitted to the projecting side bearings a^4 and a^5 and to similar elevated bearings beneath, is carried the entire length of the bed by the rack f^6 and the bevel gear pinions f^2 f^3 and the pinion f, Fig. 3. The microscope plate b^4 has a slow motion adjustment in elevation by means of an eccentric b^5, Fig. 2.

The stops c c^1 can be set at any desired position upon the bed. They can be firmly secured without the slightest disturbance of the stops, by means of large circular clamps beneath the bed-plate at e_3, Fig. 63.

The plate r extends the entire length of the bed, and is closely

fitted between the walls g and g^1, Fig. 3. It rests upon two eccentrics opposite g^5 and g^6, Fig. 1, and shown in the end view at g^1 g^2, Fig. 64. The adjustment in elevation is made by means of levers inserted in the wheels g^5 g^6.

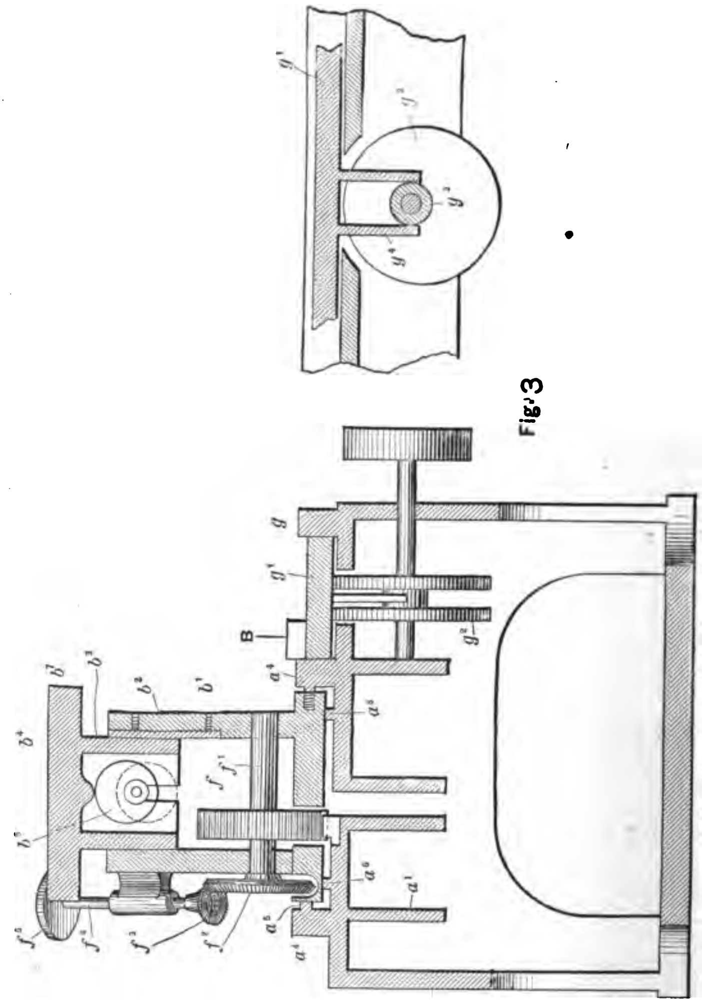


Fig. 3

The gravity lock of the microscope plate against the stops is shown in Fig. 2. The weighted lever e^6 can be thrown out of connection by means of the spring catch e^9, when it is desired to

make the contact with the stops by means of the rack and pinion movement.

The graduated bar *B* rests upon the bed of the machine and against a vertical ledge which extends the entire length.

The universal caliper $s\ s^1$ rests upon the plate *r*, and can be placed in any desired position. The two parts $s\ s^1$ move independently; s^1 being carried by two arms attached to the microscope slide b^2.

For convenience, the old comparator will be designated "Comparator A," and the new instrument will be called "Comparator B." The comparing-room in the west cellar of the Observatory will be called "Comparing-room C," and the other, "Comparing-room D."

The thermometers employed are, Farenheit thermometer Baudin 8614, and Centigrade thermometer Y O. The readings given are all reduced to the "Yale Standard." The comparisons are given in terms of the micrometer of the microscope, in which:

$$1 \text{ div.} = .503\mu.$$

An inch objective, supplied with Tolles' illuminator, was used throughout the series.

DATA FROM OBSERVATIONS.

SERIES (1).—Comparison of 15 Centimeters of $\overset{a}{S}_0$ with $\frac{15}{100}$ R_3.

Comparator B.			Comparing-room C.		
		At 62.0° F.			At 62.0° F.
Dates of Observation.	B. 8614. °	$[\frac{15}{100} R_3 - \overset{a}{S}_0]$	Dates of Observation.	B. 8614 °	$[\frac{15}{100} R_3 - \overset{a}{S}_0]$
1885, Jan. 13	17.40	+16.5 div.	Jan. 25	77.64	+20.0 div.
" 13	18.10	+22.9	" 26	81.82	+18.8
" 13	17.94	+15.9	" 26	81.84	+18.1
" 13	17.93	+16.6	" 27	31.84	+22.4
" 13	18.11	+19.0	" 27	31.68	+21.0
" 13	28.36	+23.3	" 27	32.14	+18.7
" 13	28.61	+20.9	" 27	33.06	+20.6
" 24	73.10	+22.0	Feb. 1	47.66	+20.5
" 25	74.98	+12.4	" 1	47.80	+20.1
" 25	75.00	+14.5	" 2	43.42	+21.3
" 25	77.60	+17.1	" 3	47.74	+16.6

SERIES (2).—Comparison of the first decimeter of $\overset{a}{S}_0$, $\overset{b}{S}_0$ and $\overset{c}{S}_0$ with the mean of decimeters 1, 2, 3, 4, 5 of R_3.

Comparator B. Comparing-room C.

Dates of Observation.	Y O	$\frac{1}{10} R_3 - \overset{a}{S}_0$.	$\frac{1}{10} R_3 - \overset{b}{S}_0$.	$\frac{1}{10} R_3 - \overset{c}{S}_0$.
	°			
Feb. 17	7.35	+0.4 div.	+0.4 div.	+3.8 div.
" 17	7.25	—3.1	+0.4	+3.1
" 18	5.81	+1.7	+4.0	+7.7
" 18	7.45	+1.1	+0.8	+4.0
" 19	5.56	+1.6	+0.6	+5.5
" 19	6.56	—2.2	+0.0	+2.9
" 19	6.95	—5.7	—2.9	+2.3
" 19	4.06	+0.1	—0.9	+2.2

At 16.67° C.

Dates of Observation.	Y O	[$\frac{1}{10} R_3 - \overset{a}{S}_0$.	$\frac{1}{10} R_3 - \overset{b}{S}_0$.	$\frac{1}{10} R_3 - \overset{c}{S}_0$.]
	°			
Feb. 22	21.98	—2.7 div.	—1.7 div.	+2.5 div.
" 22	20.80	—1.8	—2.1	—0.1
" 22	22.52	—2.7	—1.0	+2.0
" 22	22.32	—2.3	—0.3	+3.4
" 22	22.42	—0.5	+1.3	+5.5
" 23	21.00	—4.7	—2.6	+0.1
" 23	21.98	—2.3	—1.5	+2.7
" 24	20.78	+0.3	+1.0	+4.9

SERIES (3).—Comparison of decimeter $R_2 \frac{12\ 345}{5}$ with $\overset{a}{S}_0$, $\overset{b}{S}_0$, $\overset{c}{S}_0$.

Comparator B. Comparing-room C.

At 16.67° C.

Dates of Observation.	Y O	[$\frac{1}{10} R_2 - \overset{a}{S}_0$.	$\frac{1}{10} R_2 - \overset{b}{S}_0$.	$\frac{1}{10} R_2 - \overset{c}{S}_0$.]
	°			
Feb. 24	22.72	—1.4 div.	+1.2 div.	+4.7 div.
" 24	23.70	—1.9	+0.7	+3.6
" 25	26.51	—3.1	—1.3	+2.4
" 25	26.21	—0.6	+0.3	+2.9
" 26	25.68	—2.4	—1.6	+0.2
" 27	14.39	—0.6	+2.7	+2.6
" 27	14.19	—0.1	+4.0	+7.0
" 27	14.48	+0.1	+3.7	+4.2

SERIES (4).—Comparison of two decimeters of S_1 with $\frac{1}{3}$ R_3.

Comparator A.			Comparing-room D.		
		At 62.0° F.			At 62.0° F.
Dates of Observation.	B. 8614.	[$\frac{1}{3}$ R_3—S_1.]	Dates of Observation.	B. 8614	[$\frac{1}{3}$ R_3—S_1.]
	°			°	
Feb. 24	28.20	+15.6 div.	Feb. 26	29.10	+18.9 div.
" 24	28.40	+20.0	" 26	29.30	+20.7
" 25	30.36	+16.9	" 27	30.06	+19.7
" 25	30.20	+16.8	" 27	30.22	+18.7
" 25	29.48	+15.1	" 27	30.64	+16.3
" 25	30.26	+18.2	" 27	30.44	+17.2
" 26	30.30	+16.5	" 27	31.06	+15.1

SERIES (5).—Comparison of two decimeters of S_1 with $\frac{1}{3}$ R_2.

Comparator B.			Comparing-room C.		
		At 16.67° C.			At 16.67° C.
Dates of Observation.	Y O	[$\frac{1}{2}$ R_3—S_1.]	Dates of Observation.	Y O	[$\frac{1}{3}$ R_3—S_1.]
	°			°	
Mar. 2	24.35	+16.5 div.	Mar. 3	23.95	+16.3 div.
" 2	24.84	+18.0	" 4	14.39	+12.2
" 3	24.25	+20.3	" 4	13.58	+10.7
" 3	24.25	+13.6	" 6	14.68	+13.4
" 3	24.24	+11.7	" 8	11.56	+20.7
" 3	23.54	+19.6	" 8	11.71	+19.9
" 3	24.14	+11.1	" 8	11.41	+16.1
" 3	25.13	+23.2	" 8	11.41	+15.9
" 3	24.34	+13.8	" 9	11.86	+18.9
" 3	24.84	+18.5	" 9	11.81	+16.3
" 3	24.44	+15.1	" 9	11.91	+22.0
" 3	24.76	+19.8	" 9	11.91	+21.0
" 3	23.95	+15.9	" 10	8.63	+14.8
" 3	24.74	+20.9	" 10	8.53	+14.2

SERIES (6).—Comparison of two decimeters of S_1 with $\frac{1}{3}$ R_2.

Comparator B.			Comparing-room C.		
		At 62.0° F.			At 62.0° F.
Dates of Observation.	B. 8614.	[$\frac{1}{3}$ R_2—S_1.]	Dates of Observation.	B. 8614.	[$\frac{1}{3}$ R_2—S_1.]
	°			°	
Mar. 10	31.76	—8.8 div.	Mar. 11	29.64	—9.3 div.
" 10	31.44	—8.3	" 12	30.44	—8.0
" 11	29.87	—6.9	" 12	31.26	—4.6
" 11	30.80	—6.5	" 13	26.14	—6.5

SERIES (7).—Comparison of 2 decimeters of S_1 with $\frac{1}{5}$ R_3.

Comparator B.		At 62.0° F.	Comparing-room C.		At 62.0° F.
Dates of Observation.	Y O	$[\frac{1}{5} R_3 - \overset{a}{S_1}.]$	Dates of Observation.	B. 8614.	$[\frac{1}{5} R_2 - \overset{a}{S_1}.]$
Mar. 13	48.13°	+12.6 div.	Mar. 15	22.57°	+15.5 div.
" 13	50.81	+16.2	" 15	22.96	+17.8
" 13	48.67	+11.3	" 15	23.06	+17.6
" 15	23.15	+20.6	" 15	22.86	+11.3
" 15	22.32	+18.8	" 15	22.96	+19.5
" 15	22.18	+15.7	" 15	23.01	+19.4

SERIES (8).—Comparison of two decimeters of R_3 with $\overset{a}{S_2}$.

Comparator B.		At 16.67° C.	Comparing-room C.		At 62.0° F.
Dates of Observation.	Y O	$[\frac{1}{5} R_3 - \overset{a}{S_2}.]$	Dates of Observation.	B. 8614.	
Mar. 10	8.83°	+16.7 div.	Mar. 13	48.13°	+10.8 div.
" 10	9.43	+12.0	" 13	50.81	+15.9
" 10	9.33	+12.5	" 13	48.67	+19.9
" 11	9.93	+11.7	" 15	23.15	+19.0
" 11	10.13	+ 9.1	" 15	22.32	+15.3
" 11	10.23	+12.8	" 15	22.18	+13.0
" 11	10.42	+11.4	" 15	22.57	+13.1
" 12	7.64	+ 8.8	" 15	22.96	+16.5
" 12	7.94	+10.6	" 15	23.06	+16.0
" 12	10.82	+17.9	" 15	22.86	+18.4
" 12	12.01	+18.1	" 15	22.96	+17.6
" 13	8.48	+ 9.4	" 15	23.01	+19.5
" 13	8.68	+10.6			

SERIES (9).—Comparison of the decimeters of $\overset{a}{S}_1$ with $R_3 \frac{12345}{5}$.

Comparator B.

At 16.67° C.

Dates of Observation.	Y O °	$[\frac{1}{10} R_3 - \overset{a}{S}_1.]$ I	II
Feb. 17	7.35	+1.0 div.	+1.8 div.
" 17	7.25	—7.5	—7.4
" 18	5.81	+4.2	+5.0
" 18	7.45	+5 5	+6.9
" 19	5.56	+1.3	+2.0
" 19	7.35	+4.0	+4.8
" 19	6.56	—2.8	—3.8
" 19	6.95	—1.4	+.06

Comparing-room C.

At 16 67° C.

Dates of Observation.	Y O °	$[\frac{1}{10} R_3 - \overset{a}{S}_1.]$ I	II
Feb. 19	4.06	—2.3 div.	—0.5 div.
" 20	4.98	—3.1	+0.2
" 22	20.80	—0.2	+0.1
" 22	22.52	—2.9	—0.8
" 22	23.32	—3.6	—4.2
" 22	22.42	—3.6	—1.7
" 23	21.00	—6.7	—3.6
" 23	21.98	—2.9	+0.4
" 24	20.78	—1.2	+1.1

SERIES (10).—Comparison of the first and the second decimeters of $\overset{a}{S}_2$ with $R_0 \frac{12345}{5}$.

Comparator B.

At 16.67° C.

Dates of Observation.	Y O °	$[\frac{1}{10} R_3 - \overset{a}{S}_2.]$ I	II
Feb. 17	7.35	—0.6 div.	—0.5 div.
" 17	7.25	—4.4	—3.4
" 18	5 81	+3.7	+4.8
" 18	7.45	+4.2	+4.3
" 19	5.56	—1.8	—1.0
" 19	7.35	+4.5	+5.3
" 19	6.56	—3.8	—4.9
" 19	6.95	—3.9	—3.2

Comparing-room C.

At 16.67° C.

Dates of Observation.	Y O °	$[\frac{1}{10} R_3 - \overset{a}{S}_2.]$ I	II
Feb. 19	4.06	+1.1 div.	+1.2 div.
" 22	21.98	—1.4	—1.4
" 22	20.80	—2.2	—0.5
" 22	22.52	—1.8	—2.9
" 22	23.32	—3.6	—3.0
" 22	22.42	—3.4	—2.1
" 23	21.00	—5.0	—4.4
" 23	21.98	—1.2	—0.8
" 24	20.78	—1.6	—1.0

Series (11).—Comparison of the first and second decimeters of $\overset{a}{S}_2$ with $R_2\,\frac{12345}{5}$.

Comparator B.			
Dates of Observation.	YO	$[\frac{1}{10}R_2-\overset{a}{S}_2.]$ I	II
	°		
Feb. 24	22.72	+0.6 div.	+0.7 div.
" 24	23.70	—2.3	—1.8
" 25	26.51	+0.4	+0.4
" 25	26.24	+0.1	—0.7

Comparing-room C.			
Dates of Observation.	YO	$[\frac{1}{10}R_2-\overset{a}{S}_2.]$ I	II
	°		
Feb. 26	25.68	+2.5 div.	+2.6 div.
" 27	14.39	+2.5	+3.2
" 27	14.19	+2.1	+5.4
" 27	14.48	+2.1	+3.1

Series (12).—Comparison of the first and second decimeters of $\overset{a}{S}_2$ with $R_2\,\frac{12345}{5}$.

Comparator A. At 62.0° F.			
Dates of Observation.	B. 8614.	$[\frac{1}{10}R_3-\overset{a}{S}_2.]$ I	II
	°		
Mar. 1	32.98	—3.5 div.	—3.8 div.
" 2	32.48	—2.7	—2.8
" 2	32.06	—2.1	—2.1
" 3	32.46	+0.5	+0.9
" 3	32.20	+0.2	+2.0
" 3	32.20	—1.1	+1.3
" 4	32.54	—2.7	+1.8

Comparing-room D. At 62.0° F.			
Dates of Observation.	B. 8614.	$[\frac{1}{10}R_3-\overset{a}{S}_2.]$ I	II
	°		
Mar. 4	32.22	—1.0 div.	+0.0 div.
" 5	32.96	—0.7	+4.1
" 5	32.78	—1.7	+1.4
" 6	32.00	—3.9	—2.5
" 8	31.66	+0.5	+4.1
" 9	27.62	+2.8	+5.7

SERIES (13).—Comparison of the decimeters of $\overset{a}{S}_1$ and $\overset{a}{S}_2$.

Dates of Observation.	EQUATION BETWEEN I and II of $\overset{a}{S}_1$.	EQUATION BETWEEN I and II of $\overset{a}{S}_2$.
Mar. 16	$I - 0.7\mu = \frac{1}{2}\overset{a}{S}_1$	$I - 0.2\mu = \frac{1}{2}\overset{a}{S}_2$.
" 16	$I - 0.3 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.2 = \frac{1}{2}\overset{a}{S}_2$.
" 16	$I - 0.6 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.2 = \frac{1}{2}\overset{a}{S}_2$.
" 18	$I - 0.4 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.4 = \frac{1}{2}\overset{a}{S}_2$.
" 18	$I - 0.6 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.4 = \frac{1}{2}\overset{a}{S}_2$.
" 19	$I - 0.1 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.3 = \frac{1}{2}\overset{a}{S}_2$.
" 19	$I - 0.1 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.3 = \frac{1}{2}\overset{a}{S}_2$.
" 19	$I - 0.2 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.2 = \frac{1}{2}\overset{a}{S}_2$.
" 23	$I - 0.3 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.2 = \frac{1}{2}\overset{a}{S}_2$.
" 23	$I - 0.1 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.3 = \frac{1}{2}\overset{a}{S}_2$.
" 24	$I + 0.0 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.4 = \frac{1}{2}\overset{a}{S}_2$.
" 24	$I - 0.1 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.7 = \frac{1}{2}\overset{a}{S}_2$.
" 25	$I - 0.1 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.4 = \frac{1}{2}\overset{a}{S}_2$.
" 25	$I + 0.0 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.2 = \frac{1}{2}\overset{a}{S}_2$.
" 25	$I - 0.3 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.4 = \frac{1}{2}\overset{a}{S}_2$.
" 26	$I + 0.2 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.1 = \frac{1}{2}\overset{a}{S}_2$.
" 26	$I + 0.2 = \frac{1}{2}\overset{a}{S}_1$	$I - 0.2 = \frac{1}{2}\overset{a}{S}_2$.

SERIES (14).—Comparison of the five centimeter spaces of $\overset{a}{S}_1$ and $\overset{a}{S}_2$.

Dates of Observation.	Corrections to five centimeter spaces of $\overset{a}{S}_1$. 1	2	3	4
Feb. 1	—0.8μ	—0.1μ	+0.6μ	—0 2μ.
" 16	—0.4	—0.1	+0.6	—0.2
Mar. 19	—0.1	+0.2	+0.9	—1.0
" 22	—0.5	+0.1	+1.2	—0.8
" 22	—0.3	—0.3	+0.5	+0.0
" 23	—0.5	—0.1	+0.8	+0.1
" 24	—0.1	+0.1	+0.8	—0.6
" 25	—0.8	+0.1	+0.9	—0.1
" 26	+0.2	+0.2	+0.6	—0.8
" 26	—0.4	—0.5	+0.9	—0.4

Dates of Observation.	Corrections to five centimeter spaces of $\overset{a}{S}_2$. 1	2	3	4
Feb. 1	—0.2μ	+0.1μ	+0.8μ	—0.8μ.
" 16	—0.5	—0.2	+0.6	+0.2
Mar. 19	+0.0	+0.0	+0.4	—0.4
" 22	—0.3	+0.9	+0.6	—1.2
" 22	—0.2	+0.2	+0.8	—0.6
" 23	+0.6	+0.0	+0.4	—0.8
" 24	—0.1	—0.2	+0.4	—0.1
" 25	—0.2	+0.1	+0.5	—0.5
" 26	—0.5	—0.4	+1.0	—0.3
" 26	—0.7	+0.0	+0.6	+0.0

Collecting results we have:

From Series (13).

First decimeter of $\overset{a}{S}_1$—0.19μ=$\frac{1}{2}$ $\overset{a}{S}_1$.

First decimeter of $\overset{a}{S}_2$—0.30μ=$\frac{1}{2}$ $\overset{a}{S}_2$.

From Series (14).

Correction of five centimeter spaces of $\overset{a}{S}_1$.

		Σ
1	-0.37μ	-0.37μ.
2	-0.01μ	-0.38μ.
3	$+0.78\mu$	$+0.40\mu$.
4	-0.40μ	$+0.00\mu$.

Corrections to five centimeter spaces of $\overset{a}{S}_2$.

		Σ
1	-0.21μ	-0.21μ.
2	$+0.05\mu$	-0.16μ.
3	$+0.61\mu$	$+0.45\mu$.
4	-0.45μ	$+0.00\mu$.

It will be seen that the corrections to the decimeter spaces derived from the summation of the corrections to the five centimeter spaces are 0.38μ and 0.16μ, respectively. Taking the mean between these values and the values found by direct comparison we have:

First decimeter of $\overset{a}{S}_1$—0.28μ=$\frac{1}{2}$ $\overset{a}{S}_1$.

First decimeter of $\overset{a}{S}_2$—0.23μ=$\frac{1}{2}$ $\overset{a}{S}_2$.

SERIES (15.) Direct comparison of $\overset{a}{S}_0$, $\overset{b}{S}_0$ and $\overset{c}{S}_0$.

Dates of Observation.	$\overset{a}{S}_0-\overset{b}{S}_0$.	$\overset{a}{S}_0-\overset{c}{S}_0$.	$\overset{b}{S}_0-\overset{c}{S}_0$.
Mar. 30	$+0.3\mu$	$+1.7\mu$	$+1.4\mu$
" 30	$+0.7$	$+3.2$	$+2.5$
Ap'l 1	$+0.4$	$+2.3$	$+1.9$
" 1	-0.1	$+2.6$	$+2.7$
Means	$+0.32\mu$	$+2.45\mu$	$+2.12\mu$

Series (16).

Direct comparison of five centimeter spaces of $\overset{a}{S}_0$, $\overset{b}{S}_0$ and $\overset{c}{S}_0$.

Dates of Observation.	$\overset{a}{S}_0$. 1	2	3
Mar. 29	$+1.1\mu$	-0.6μ	-0.5μ
" 30	$+0.8$	-0.5	-0.3
" 31	$+1.1$	-0.7	-0.4
Means	$+1.00\mu$	-0.60μ	-0.40μ

Dates of Observation.	$\overset{b}{S}_0$. 1	2	3	$\overset{c}{S}_0$. 1	2	3
Mar. 29	-0.0μ	$+0.5\mu$	-0.5μ	-0.5μ	$+1.2\mu$	-0.7μ.
" 30	$+0.4$	$+0.5$	-0.9	-0.9	$+1.8$	-0.9
" 31	$+0.1$	$+0.8$	-0.9	-0.7	$+1.5$	-0.8
Means	$+0.17\mu$	$+0.57\mu$	-0.74μ	-0.70μ	$+1.50\mu$	-0.80μ

Series (17).—Direct comparison of the two decimeters of $\overset{a}{S}_1$ and of $\overset{a}{S}_2$.

Dates of Observation.	$\overset{a}{S}_1-\overset{a}{S}_2$.	Dates of Observations.	$\overset{a}{S}_1-\overset{a}{S}_2$.
April 1	-0.8μ.	April 2	-1.1μ.
" 1	-1.1	" 2	-0.6
" 1	-0.8	" 3	-0.4
" 1	-0.4	" 3	-1.4
" 1	-1.2	" 3	-1.4
" 1	-1.0		

Hence: $\overset{a}{S}_1-\overset{a}{S}_2=-0.93\mu$.

Independent determinations of the relations between the decimeters of $\overset{a\,b\,c}{S_0}$, $\overset{a}{S}_1$, $\overset{a}{S}_2$ and $\frac{1}{10}$ A_0.

From a combination of the results obtained from Series (c) to Series (g), pages 170 to 176, we have:

$$\overset{a}{S}_0-6.3\mu=\tfrac{1}{2}\,R_3\,(I)=\tfrac{1}{2}\,A_0-1.3\mu \text{ and } \overset{a}{S}_0-5.0\mu=\tfrac{1}{2}\,A_0.$$

$$\overset{b}{S}_0-5.3\mu=\tfrac{1}{2}\,R_3\,(I)=\tfrac{1}{2}\,A_0-1.3\mu \qquad \overset{b}{S}_0-4.0\mu=\tfrac{1}{2}\,A_0.$$

$$\overset{c}{S}_0+4.8\mu=\tfrac{1}{2}\,R_3\,(I)=\tfrac{1}{2}\,A_0-1.3\mu \qquad \overset{c}{S}_0+6.1\mu=\tfrac{1}{2}\,A_0.$$

Hence, disregarding the relative errors of the sub-divisions we have:

$$\text{First decimeter of } \overset{a}{S}_0 - 1.0\mu = \tfrac{1}{10} A_0.$$
$$\text{First decimeter of } \overset{b}{S}_0 - 0.8\mu = \tfrac{1}{10} A_0.$$
$$\text{First decimeter of } \overset{c}{S}_0 + 1.2\mu = \tfrac{1}{10} A_0.$$

Referring to page 190 and combining the relative corrections of the first decimeter of $\overset{a}{S}_0$, $\overset{b}{S}_0$ and $\overset{c}{S}_0$, with the relations given above, we have for the total corrections to the first decimeters of S_0:

$$\tfrac{1}{5}\overset{a}{S}_0 + 0.3\mu - 1.0\mu = \tfrac{1}{10} A_0, \text{ or } \tfrac{1}{5}\overset{a}{S}_0 - 0.7\mu = \tfrac{1}{10} A_0.$$
$$\tfrac{1}{5}\overset{b}{S}_0 + 1.2\mu - 0.8\mu = \tfrac{1}{10} A_0, \quad \tfrac{1}{5}\overset{b}{S}_0 + 0.4\mu = \tfrac{1}{10} A_0.$$
$$\tfrac{1}{5}\overset{c}{S}_0 + 0.4\mu + 1.2\mu = \tfrac{1}{10} A_0, \quad \tfrac{1}{5}\overset{c}{S}_0 + 1.6\mu = \tfrac{1}{10} A_0.$$

From Series (1), page 181, we have:

$$15 \text{ centimeters of } \overset{a}{S}_0 - 0.9\mu = \tfrac{3}{20} A_0.$$

From page 189,

$$\overset{a}{S}_0 - \overset{b}{S}_0 = +0.3\mu. \qquad \overset{a}{S}_0 - \overset{c}{S}_0 = +2.5\mu.$$

Hence: $\tfrac{3}{10}\overset{b}{S}_0 - 0.6\mu = \tfrac{3}{20} A_0.$ $\tfrac{3}{10}\overset{c}{S}_0 + 1.6\mu = \tfrac{3}{20} A_0.$

From Series (16), and from the relation between $\overset{a\,b\,c}{S_0}$ and $\tfrac{1}{2} A_0$ given on page 190, we have:

Spaces.	Corrections to $\overset{a}{S}_0$.			Σ
1	$+1.0\mu$	-0.5μ	$= +0.5\mu$	$+0.5\mu$.
2	-0.6	-0.5	$= -1.1$	-0.6
3	-0.4	-0.5	$= -0.9$	-1.5

Spaces.	Corrections to $\overset{b}{S}_0$.			Σ	Corrections to $\overset{c}{S}_0$.			Σ
1	$+0.2\mu$	-0.4μ	$= -0.2\mu$	-0.2μ.	-0.7μ	$+0.6\mu$	$= -0.1\mu$	-0.1μ.
2	$+0.6$	-0.4	$= +0.2$	$+0.0$	$+1.5$	$+0.6$	$= +2.1$	$+2.0$
3	-0.7	-0.4	$= -1.1$	-1.1	-0.8	$+0.6$	$= -0.2$	$+1.8$

We have, therefore:

For the first 5 centimeters.	For the first decimeter.	For the first 15 centimeters.
$\frac{1}{10}\overset{a}{S}_0+0.5\mu=\frac{1}{20}A_0.$	$\frac{1}{10}\overset{b}{S}_0-0.2\mu=\frac{1}{20}A_0.$	$\frac{1}{10}\overset{c}{S}_0-0.1\mu=\frac{1}{20}A_0.$
$\frac{1}{5}\overset{a}{S}_0-0.6\mu=\frac{1}{10}A_0.$	$\frac{1}{5}\overset{b}{S}_0+0.0\mu=\frac{1}{10}A_0.$	$\frac{1}{5}\overset{c}{S}_0+2.0\mu=\frac{1}{10}A_0.$
$\frac{3}{10}\overset{a}{S}_0-1.5\mu=\frac{3}{20}A_0.$	$\frac{3}{10}\overset{b}{S}_0-1.1\mu=\frac{3}{20}A_0.$	$\frac{3}{10}\overset{c}{S}_0+1.8\mu=\frac{3}{20}A_0.$

From Series (2) and Series (3) we have:

From comparison with R_3.

$$\frac{1}{5}\overset{a}{S}_0-0.7\mu=\frac{1}{10}R_3=\frac{1}{10}A_0-0.2\mu.$$
$$\frac{1}{5}\overset{b}{S}_0-0.2\mu=\frac{1}{10}R_3=\frac{1}{10}A_0-0.2\mu.$$
$$\frac{1}{5}\overset{c}{S}_0+1.7\mu=\frac{1}{10}R_3=\frac{1}{10}A_0-0.2\mu.$$

From comparison with R_2.

$$\frac{1}{5}\overset{a}{S}_0-0.6\mu=\frac{1}{10}R_2=\frac{1}{10}A_0-0.2\mu.$$
$$\frac{1}{5}\overset{b}{S}_0+0.6\mu=\frac{1}{10}R_2=\frac{1}{10}A_0-0.2\mu.$$
$$\frac{1}{5}\overset{c}{S}_0+1.8\mu=\frac{1}{10}R_2=\frac{1}{10}A_0-0.2\mu.$$

Whence:

$\frac{1}{5}\overset{a}{S}_0-0.5\mu=\frac{1}{10}A_0.$	$\frac{1}{5}\overset{a}{S}_0-0.4\mu=\frac{1}{10}A_0.$
$\frac{1}{5}\overset{b}{S}_0+0.0\mu=\frac{1}{10}A_0.$	$\frac{1}{5}\overset{a}{S}_0+0.8\mu=\frac{1}{10}A_0.$
$\frac{1}{5}\overset{c}{S}_0+1.9\mu=\frac{1}{10}A_0.$	$\frac{1}{5}\overset{b}{S}_0+2.0\mu=\frac{1}{10}A_0.$

Collecting the separate results we have the following corrections for the first decimeters of $\overset{a\,b\,c}{S}_0$:

Corrections

For $\frac{1}{5}\overset{a}{S}_0$.	For $\frac{1}{5}\overset{b}{S}_0$.	For $\frac{1}{5}\overset{c}{S}_0$.
-0.9μ	-0.6μ	$+1.6\mu$
-0.6μ	$+0.0\mu$	$+2.0\mu$
-0.5μ	$+0.0\mu$	$+1.9\mu$
$-04.\mu$	$+0.8\mu$	$+2.0\mu$

Or, finally:

$$\tfrac{1}{5}\overset{a}{S}_0 - 0.60\mu = \tfrac{1}{10}A_0. \quad \tfrac{1}{5}\overset{b}{S}_0 + 0.05\mu = \tfrac{1}{10}A_0. \quad \tfrac{1}{5}\overset{c}{S}_0 + 1.88 = \tfrac{1}{10}A_0.$$

And for the first five centimeters:

$$\tfrac{1}{10}\overset{a}{S}_0 + 0.5\mu = \tfrac{1}{20}A_0. \quad \tfrac{1}{10}\overset{b}{S}_0 - 0.2\mu = \tfrac{1}{20}A_0. \quad \tfrac{1}{10}\overset{c}{S}_0 - 0.1\mu = \tfrac{1}{20}A_0.$$

For the relation between the two decimeters of $\overset{a}{S}_1$ in terms of $\frac{1}{10}$ A_0 we have:

From Series (4), $\overset{a}{S}_1 + 1.1\mu = \frac{1}{5}A_0$.

From Series (5), $\overset{a}{S}_1 + 1.4\mu = \frac{1}{5}A_0$.

From Series (6), $\overset{a}{S}_1 + 0.2\mu = \frac{1}{5}A_0$.

From Series (7), $\overset{a}{S}_1 + 1.2\mu = \frac{1}{5}A_0$.

Hence $\frac{2}{5}\overset{a}{S}_1 + 0.98\mu = \frac{1}{5}A_0$.

Noting the relations between the first and the second decimeters given on page 189 we have:

First decimeter of $\overset{a}{S}_1 + 0.2\mu = \frac{1}{10}A_0$.

From Series (9). First decimeter of $\overset{a}{S}_1 - 0.1\mu = \frac{1}{10}A_0$.

Hence, finally:

First decimeter of $\overset{a}{S}_1 + 0.05\mu = -\frac{1}{10}A_0$.

First 5 centimeter space of $\overset{a}{S}_1 - 0.1\mu = \frac{1}{20}A_0$.

For the relation between the two decimeters of S_2 and $\frac{1}{10}$ A_0 we have:

From Series (8), $\frac{2}{5}\overset{a}{S}_2 + 0.2\mu = \frac{1}{5}A_0$.

Hence:

	First decimetor of		$\overset{a}{S}_2$	$+0.0\mu = \frac{1}{10}A_0$.
From Series (10),	"	"	"	$-0.3\mu = \frac{1}{10}A_0$.
From Series (10),	"	"	"	$-0.4\mu = \frac{1}{10}A_0$.
From Series (11),	"	"	"	$+0.5\mu = \frac{1}{10}A_0$.
From Series (11),	"	"	"	$+0\ 6\mu = \frac{1}{10}A_0$.
From Series (12),	"	"	"	$-0.5\mu = \frac{1}{10}A_0$.
From Series (12),	"	"	"	$+0.2\mu = \frac{1}{10}A_0$.

Hence, finally:

First decimeter of $\overset{a}{S}_2 - 0.01\mu - \frac{1}{10} A_0$.

First 5 centimeter space of $\overset{a}{S}_2 - 0.2\mu - \frac{1}{20} A_0$.

It must be carefully noted that all of these relations hold for 6.20° F., or for 16.67° C.

Comparison of the Rowland gratings with $\overset{a}{S}_0$, $\overset{b}{S}_0$, $\overset{c}{S}_0$, $\overset{a}{S}_1$ and $\overset{a}{S}_2$.

The decimeter gratings are designated $\overset{1}{R}_1$, $\overset{2}{R}_1$, $\overset{3}{R}_1$, $\overset{4}{R}_1$. and the five centimeter gratings are designated $\overset{1}{R}_2$, $\overset{2}{R}_2$, $\overset{3}{R}_2$, $\overset{4}{R}_2$.

Dates of Observation.	$\overset{a}{S}_0 - \overset{1}{R}_1$.	$\overset{b}{S}_0 - \overset{1}{R}_1$.	$\overset{c}{S}_0 - \overset{1}{R}_1$.	$\overset{a}{S}_1 - \overset{1}{R}_1$.	$\overset{a}{S}_2 - \overset{1}{R}_1$.
Feb. 1	+127.3div.	+125.4div.	+121.9div.	+128.7div.	+129.0div.
2	128.1	125.3	121.9	129.0	129.5
3	128.8	127.8	125.5	128.8	130.5
4	123.9	128.9	127.2	127.5	127.7
5	127.2	128.6	128.6	129.8	132.5
6	130.6	126.2	123.9	129.8	130.5
6	129.1	126.6	124.2	127.8	131.4
7	129.8	124.9	120.2	128.4	126.2
17	130.5	127.0	124.3	134.9	131.4
18	128.1	123.6	120.1	123.6	125.1

	$\overset{a}{S}_0 - \overset{2}{R}_1$.	$\overset{b}{S}_0 - \overset{2}{R}_1$.	$\overset{c}{S}_0 - \overset{2}{R}_1$.	$\overset{a}{S}_1 - \overset{2}{R}_1$.	$\overset{a}{S}_2 - \overset{2}{R}_1$.
Feb. 1	+130.3div.	+128.4div.	+124.9div.	+131.7div.	+132.0div.
2	130.6	127.8	124.4	131.5	132.0
3	127.9	126.9	124.6	127.9	129.6
4	128.1	126.1	126.4	131.7	131.9
5	129.8	129.2	124.2	132.4	135.1
6	129.3	124.9	122.6	128.5	129.2
6	129.8	127.3	124.9	128.5	132.1
7	129.7	125.0	126.3	128.5	126.3
17	129.8	126.3	123.6	134.2	130.7
18	130.3	125.8	122.3	125.8	127.3

Dates of Observation.	$\overset{a}{S}_0—\overset{3}{R}_1$.	$\overset{b}{S}_0—\overset{3}{R}_1$.	$\overset{c}{S}_0—\overset{3}{R}_1$.	$\overset{a}{S}_1—\overset{3}{R}_1$.	$\overset{a}{S}_2—\overset{3}{R}_1$.
Feb. 1	+129.0div.	+127.1div.	+125.6div.	+130.4div.	+130.7div.
2	128.1	125.3	121.9	129.0	129.5
3	128.4	127.4	125.1	128.4	130.1
4	128.5	126.5	121.8	132.1	132.3
5	129.8	124.2	124.2	132.4	130.1
6	127.5	128.1	126.8	126.7	127.4
6	131.8	129.3	126.9	130.5	134.1
7	131.0	126.1	121.4	129.6	127.4
17	130.3	126.8	124.1	134.7	131.2
18	129.5	125.0	121.5	125.0	126.5

	$\overset{a}{S}_0—\overset{4}{R}_1$.	$\overset{b}{S}_0—\overset{4}{R}_1$.	$\overset{c}{S}_0—\overset{4}{R}_1$.	$\overset{a}{S}_1—\overset{4}{R}_1$:	$\overset{a}{S}_2—\overset{4}{R}_1$.
Feb. 1	+127.7div.	+125.8div.	+122.3div.	+129.1div.	+129.4div.
2	128.7	125.9	122.5	129.6	130.1
3	126.0	125.0	122.7	126.0	127.7
4	129.3	127.3	122.6	127.9	127.1
5	127.3	126.7	126.7	129.9	127.6
6	128.8	124.4	122.1	128.0	128.7
6	129.5	127.0	124.6	128.2	131.8
7	131.4	126.5	121.8	130.0	127.8
17	128.3	124.8	122.1	132.7	129.2
18	129.3	124.8	121.3	124.8	126.3

Dates of Observation.	$\overset{a}{S}_0—\overset{1}{R}_2$.	$\overset{b}{S}_0—\overset{1}{R}_2$.	$\overset{c}{S}_0—\overset{1}{R}_2$.	$\overset{a}{S}_1—\overset{1}{R}_2$	$\overset{a}{S}_2—\overset{1}{R}_2$.
Feb. 6	+66.2 div.	+69.0 div.	+68.8 div.	+68.5 div.	+67.3 div.
7	64.7	66.3	65.9	67.7	67.9
7	62.2	65.4	64.4	63.8	63.7
8	64.3	66.5	65.9	64.7	64.5
9	63.1	64.1	62.8	65.9	64.9
12	62.2	63.4	63.6	63.9	64.3
13	65.3	67.0	64.4	68.3	68.3
15	67.8	70.7	69.3	70.3	72.0
15	64.7	67.0	65.0	64.9	66.5
16	65.6	67.5	68.1	68.5	68.4

	$S^a_0-R^2_2$.	$S^b_0-R^2_2$.	$S^c_0-R^2_2$.	$S^a_1-R^2_2$.	$S^a_2-R^2_2$.
Feb. 6	+64.0 div.	+66.8 div.	+66.6 div.	+66.3 div.	+65.1 div.
7	62.8	64.4	64.0	65.8	66.0
7	62.7	65.9	64.9	64.3	64.2
8	64.4	66.6	66.0	64.8	64.6
9	62.2	63.2	61.9	65.0	64.0
12	61.4	62.6	62.8	63.1	63.5
13	62.0	63.7	61.1	65.0	65.0
15	63.6	66.5	65.1	66.1	67.8
15	64.5	66.8	64.8	64.7	66.3
16	63.6	65.5	66.1	66.5	66.4

Dates of Observation.	$S^a_0-R^3_2$.	$S^b_0-R^3_2$.	$S^c_0-R^3_2$.	$S^a_1-R^3_2$.	$S^a_2-R^3_2$.
Feb. 6	+63.9 div.	+66.7 div.	+66.5 div.	+66.2 div.	+65.0 div.
7	62.9	64.5	64.1	65.9	66.1
7	61.8	65.0	64.0	63.4	63.3
8	65.3	67.5	66.9	65.7	65.5
9	65.6	66.6	65.3	68.4	67.4
12	65.5	66.7	66.9	67.2	67.6
13	63.2	64.9	62.3	66.2	66.2
15	66.0	68.9	67.5	68.5	70.2
15	63.8	66.1	64.1	64.0	65.6
16	65.0	66.9	67.5	67.9	67.8

	$S^a_0-R^4_2$.	$S^b_0-R^4_2$.	$S^c_0-R^4_2$.	$S^a_1-R^4_2$.	$S^a_2-R^4_2$.
Feb. 6	+67.8 div.	+70.6 div.	+70.4 div.	+70.1 div.	+68.9 div.
7	65.0	66.6	66.2	68.0	68.2
7	67.9	71.1	70.1	69.5	69.4
8	65.7	67.9	67.3	66.1	65.9
9	64.9	65.9	64.6	67.7	66.7
12	65.0	66.2	66.4	66.7	67.1
13	63.9	65.6	63.0	66.9	66.9
15	66.8	69.7	68.3	69.3	71.0
15	64.0	66.3	64.3	64.2	65.8
16	63.7	65.6	66.2	66.6	66.5

We have now, as the result of our inquiry:

$S^a_0 - R^1_1 = +128.3$ div. $= +64.5\mu$ whence $R^1_1 + 63.9\mu = \frac{1}{10} A_0$.
$S^b_0 - R^1_1 = +126.4 \quad = +63.6 \quad R^1_1 + 63.6 = \frac{1}{10} A_0$.
$S^c_0 - R^1_1 = +123.8 \quad = +62.3 \quad R^1_1 + 64.2 = \frac{1}{10} A_0$.
$S^a_1 - R^1_1 = +128.8 \quad = +64.8 \quad R^1_1 + 64.7 = \frac{1}{10} A_0$.
$S^a_2 - R^1_1 = +129.4 \quad = +65.1 \quad R^1_1 + 65.1 = \frac{1}{10} A_0$.

Therefore: $\mathbf{R^1_1 + 64.30\mu = \frac{1}{10} A_0}$.

$S^a_0 - R^2_1 = +129.6$ div. $= +65.2\mu$ whence $R^2_1 + 64.6\mu = \frac{1}{10} A_0$.
$S^b_0 - R^2_1 = +126.8 \quad = +63.8 \quad R^2_1 + 63.8 = \frac{1}{10} A_0$.
$S^c_0 - R^2_1 = +124.4 \quad = +62.6 \quad R^2_1 + 64.5 = \frac{1}{10} A_0$.
$S^a_1 - R^2_1 = +130.1 \quad = +65.4 \quad R^2_1 + 65.3 = \frac{1}{10} A_0$.
$S^a_2 - R^2_1 = +130.8 \quad = +65.9 \quad R^2_1 + 65.9 = \frac{1}{10} A_0$.

Therefore: $\mathbf{R^2_1 + 64.82\mu = \frac{1}{10} A_0}$.

$S^a_0 - R^3_1 = +129.4$ div. $= +65.1\mu$ whence $R^3_1 + 64.5\mu = \frac{1}{10} A_0$.
$S^b_0 - R^3_1 = +126.6 \quad = +63.7 \quad R^3_1 + 63.8 = \frac{1}{10} A_0$.
$S^c_0 - R^3_1 = +123.9 \quad = +62.4 \quad R^3_1 + 64.3 = \frac{1}{10} A_0$.
$S^a_1 - R^3_1 = +129.9 \quad = +65.4 \quad R^3_1 + 65.3 = \frac{1}{10} A_0$.
$S^a_2 - R^3_1 = +129.3 \quad = +65.0 \quad R^3_1 + 65.0 = \frac{1}{10} A_0$.

Therefore: $\mathbf{R^3_1 + 64.58\mu = \frac{1}{10} A_0}$.

$S^a_0 - R^4_1 = +128.6$ div. $= +64.7\mu$ whence $R^4_1 + 64.1\mu = \frac{1}{10} A_0$.
$S^b_0 - R^4_1 = +125.8 \quad = +63.3 \quad R^4_1 + 63.4 = \frac{1}{10} A_0$.
$S^c_0 - R^4_1 = +122.9 \quad = +61.8 \quad R^4_1 + 63.7 = \frac{1}{10} A_0$.
$S^a_1 - R^4_1 = +128.6 \quad = +64.7 \quad R^4_1 + 64.7 = \frac{1}{10} A_0$.
$S^a_2 - R^4_1 = +128.6 \quad = +64.7 \quad R^4_1 + 64.7 = \frac{1}{10} A_0$.

Therefore: $\mathbf{R^4_1 + 64\ 12\mu = \frac{1}{10} A_0}$.

$\overset{a}{S}_0 - \overset{1}{R}_2 = +64.6$ div.	$= +32.5\mu$	whence	$\overset{5}{R}_1 + 33.0\mu = \frac{1}{20} A_0$.
$\overset{b}{S}_0 - \overset{1}{R}_2 = +66.7$	$= +33.6$		$\overset{5}{R}_1 + 33.4 = \frac{1}{20} A_0$.
$\overset{c}{S}_0 - \overset{1}{R}_2 = +65.8$	$= +33.1$		$\overset{5}{R}_1 + 33.0 = \frac{1}{20} A_0$.
$\overset{a}{S}_1 - \overset{1}{R}_2 = +66.6$	$= +33.5$		$\overset{5}{R}_1 + 33.4 = \frac{1}{20} A_0$.
$\overset{a}{S}_2 - \overset{1}{R}_2 = +66.8$	$= +33.6$		$\overset{5}{R}_1 + 33.4 = \frac{1}{20} A_0$.

Therefore: $\quad \overset{1}{R}_2 + 33.24\mu = \frac{1}{20} A_0$.

$\overset{a}{S}_0 - \overset{2}{R}_2 = +63.1$ div.	$= +31.7\mu$	whence	$\overset{6}{R}_1 + 32.2\mu = \frac{1}{20} A_0$.
$\overset{b}{S}_0 - \overset{2}{R}_2 = +65.2$	$= +32.8$		$\overset{6}{R}_1 + 32.6 = \frac{1}{20} A_0$.
$\overset{c}{S}_0 - \overset{2}{R}_2 = +64.3$	$= +32.3$		$\overset{6}{R}_1 + 32.1 = \frac{1}{20} A_0$.
$\overset{a}{S}_1 - \overset{2}{R}_2 = +65.2$	$= +32.8$		$\overset{6}{R}_1 + 32.7 = \frac{1}{20} A_0$.
$\overset{a}{S}_2 - \overset{2}{R}_2 = +65.3$	$= +32.8$		$\overset{6}{R}_1 + 32.6 = \frac{1}{20} A_0$.

Therefore: $\quad \overset{2}{R}_2 + 32.44\mu = \frac{1}{20} A_0$.

$\overset{a}{S}_0 - \overset{3}{R}_2 = +64.3$ div.	$= +32.3\mu$	whence	$\overset{7}{R}_1 + 32.8\mu = \frac{1}{20} A_0$.
$\overset{b}{S}_0 - \overset{3}{R}_2 = +66.4$	$= +33.4$		$\overset{7}{R}_1 + 33.2 = \frac{1}{20} A_0$.
$\overset{c}{S}_0 - \overset{3}{R}_2 = +65.5$	$= +32.9$		$\overset{7}{R}_1 + 32.8 = \frac{1}{20} A_0$.
$\overset{a}{S}_1 - \overset{3}{R}_2 = +66.3$	$= +33.3$		$\overset{7}{R}_1 + 33.1 = \frac{1}{20} A_0$.
$\overset{a}{S}_2 - \overset{3}{R}_2 = +66.5$	$= +33.4$		$\overset{7}{R}_1 + 33.2 = \frac{1}{20} A_0$.

Therefore: $\quad \overset{3}{R}_2 + 33.02\mu = \frac{1}{20} A_0$.

$\overset{a}{S}_0 - \overset{4}{R}_2 = +65.5$ div.	$= +32.9\mu$	whence	$\overset{8}{R}_1 + 33.4\mu = \frac{1}{20} A_0$.
$\overset{b}{S}_0 - \overset{4}{R}_2 = +67.5$	$= +34.0$		$\overset{8}{R}_1 + 33.8 = \frac{1}{20} A_0$.
$\overset{c}{S}_0 - \overset{4}{R}_2 = +66.7$	$= +33.6$		$\overset{8}{R}_1 + 33.5 = \frac{1}{20} A_0$.
$\overset{a}{S}_1 - \overset{4}{R}_2 = +67.5$	$= +34.0$		$\overset{8}{R}_1 + 33.9 = \frac{1}{20} A_0$.
$\overset{a}{S}_2 - \overset{4}{R}_2 = +67.6$	$= +34.0$		$\overset{8}{R}_1 + 33.8 = \frac{1}{20} A_0$.

Therefore: $\quad \overset{4}{R}_2 + 33.68\mu = \frac{1}{20} A_0$.

THE NUMERICAL APERTURE OF AN OBJECTIVE IN RELATION TO ITS ANGLE OF APERTURE IN AIR, WATER AND BALSAM.

By H. J. DETMERS, M. V. D., F. R. M. S., Columbus, O.

NUMER. APERT. n sin. u	AIR ANGLE. n — 1. °	WATER ANGLE. n — 1.33. ° ′	BALSAM ANGLE. n — 1.52. ° ′
.008 7265	1	0. 45	0. 39
.017 45241	2	1. 30	1. 19
.034 89516	4	3. 00	2. 38
.052 3359	6	4. 31	3. 57
.069 7566	8	6. 1	5. 16
.087 1578	10	7. 31	6. 34
.104 5286	12	9. 1	7. 53
.121 8612	14	10. 31	9. 12
.139 1730	16	12. 1	10. 30
.156 4342	18	13. 31	11. 49
.173 6480	20	15. 00	13. 7
.190 8092	22	16. 30	14. 25
.207 9120	24	18. 00	15. 43
.224 9513	26	19. 29	17. 1
.241 9217	28	20. 58	18. 19
.258 8190	30	22. 27	19. 36
.275 6373	32	23. 55	20. 53
.292 3712	34	25. 23	22. 10
.309 0171	36	26. 52	23. 27
.325 5684	38	28. 20	24. 44
.342 0206	40	29. 48	26. 00
.358 3678	42	31. 16	27. 16
.374 6060	44	32. 43	28. 32
.390 7315	46	34. 10	29. 47
.406 7364	48	35. 37	31. 3
.422 6184	50	37. 3	32. 17
.438 3707	52	38. 29	33. 32
.453 9906	54	39. 55	34. 46
.469 4710	56	41. 20	35. 59

NUMER. APERT. n sin. u	AIR ANGLE. n = 1. °	WATER ANGLE. n = 1.33. ° ′	BALSAM ANGLE. n = 1.52. ° ′
.484 8089	58	42. 45	37. 12
.500 0000	60	44. 10	38. 25
.515 0381	62	45. 34	39. 37
.529 9190	64	46. 58	40. 49
.544 6387	66	48. 21	42. 00
.559 1936	68	49. 44	43. 10
.573 5763	70	51. 6	44. 20
.587 7851	72	52. 27	45. 30
.601 8153	74	53. 48	46. 39
.615 6620	76	55. 9	47. 47
.629 3203	78	56. 29	48. 55
.642 7868	80	57. 48	50. 2
.656 0591	82	59. 7	51. 8
.669 1308	84	60. 25	52. 14
.681 9984	86	61. 42	53. 19
.694 6746	88	62. 58	54. 23
.707 1066	90	64. 14	55. 27
.719 3400	92	65. 29	56. 29
.731 3525	94	66. 43	57. 31
.743 1448	96	67. 56	58. 32
.754 7103	98	69. 9	59. 32
.766 0439	100	70. 20	60. 32
.777 1464	102	71. 31	61. 30
.788 1090	104	72. 41	62. 28
.798 6370	106	73. 49	63. 24
.809 0167	108	74. 56	64. 19
.819 1528	110	76. 2	65. 13
.829 0365	112	77. 7	66. 6
.838 6692	114	78. 11	66. 58
.848 0471	116	79. 14	67. 49
.857 1686	118	80. 15	68. 39
.866 0260	120	81. 15	69. 28
.874 6200	122	82. 14	70. 15
.882 9469	124	83. 11	71. 1
.891 0061	126	84. 8	71. 46
.898 7938	128	85. 2	72. 30
.906 3083	130	85. 55	73. 12
.913 5438	132	86. 46	73. 53
.920 5043	134	87. 35	74. 33
.927 1851	136	88. 24	75. 11
.933 5808	138	89. 10	75. 47
.939 6935	140	89. 54	76. 22
.945 5174	142	90. 37	76. 56

NUMER. APERT. n sin. u	AIR ANGLE. n = 1. °	WATER ANGLE. n = 1.33. ° ′	BALSAM ANGLE. n = 1.52. ° ′
.951 0565	144	91. 18	77. 28
.956 3044	146	91. 57	77. 58
.961 2622	148	92. 34	78. 27
.965 9267	150	93. 9	78. 55
.970 2956	152	93. 42	79. 20
.974 3711	154	94. 13	79. 44
.978 1455	156	94. 41	80. 7
.981 6273	158	95. 8	80. 27
.984 8068	160	95. 32	80. 46
.987 6886	162	95. 55	81. 3
.990 2682	164	96. 15	81. 19
.992 5455	166	96. 32	81. 32
.994 5205	168	96. 48	81. 44
.996 1932	170	97. 1	81. 54
.997 5659	172	97. 11	82. 2
.998 6286	174	97. 20	82. 8
.999 3909	176	97. 26	82. 13
.999 8465	178	97. 29	82. 16
1.000 0000	180	97. 30 12″	82. 17

THE NUMERICAL APERTURE OF AN OBJECTIVE IN RELATION TO ITS ANGLE OF APERTURE IN BALSAM AND IN WATER.

NUMER. APERT. n sin. u	BALS. A. n = 1.52. °	WATER A. n = 1.33.	NUMER. APER. n sin. u	BALS. A. n = 1.52. °	WATER A. n = 1.33. ° ′
.013 264 28	1	1. 9	.341 925 976	26	29. 48
.026 527 66	2	2. 17	.367 720 984	28	32. 6
.053 040 64	4	4. 34	.393 404 880	30	34. 25
.079 550 568	6	6. 51	.418 968 696	32	36. 43
.106 030 032	8	9. 9	.444 404 224	34	39. 2
.132 479 856	10	11. 26	.469 705 992	36	41. 22
.158 883 472	12	13. 43	.494 863 968	38	43. 41
.185 229 024	14	16. 1	.519 871 312	40	46. 1
.211 542 960	16	18. 18	.544 719 056	42	48. 21
.237 779 984	18	20. 36	.569 401 120	44	50. 42
.263 944 960	20	22. 54	.593 911 880	46	53. 3
.290 029 984	22	25. 11	.618 239 328	48	55. 24
.316 026 240	24	27. 29	.642 379 968	50	57. 46

NUMER. APERT. n sin. u	BALS. A. n — 1.52. °	WATER A. n — 1.33. ° '	NUMER. APERT. n sin. u	BALS. A. n — 1.52. °	WATER A. n — 1.33. ° '
.666 323 464	52	60. 8	1.017 078 816	84	99. 46
.690 065 712	54	62. 31	1.036 637 568	86	102. 25
.713 595 920	56	64. 54	1.055 905 392	88	105. 6
.736 909 528	58	67. 18	1.074 802 032	90	107. 50
.760 000 000	60	69. 42	1.093 396 800	92	110. 36
.782 857 912	62	72. 7	1.111 655 800	94	113. 24
.805 476 880	64	74. 33	1.129 580 096	96	116. 16
.827 850 824	66	77. 00	1.147 159 656	98	119. 12
.849 974 272	68	79. 27	1.164 386 728	100	122. 12
.871 835 976	70	81. 55	1.181 262 528	102	125. 19
.893 433 352	72	84. 24	1.197 925 680	104	128. 28
.914 759 256	74	86. 54	1.213 928 240	106	131. 46
.935 796 240	76	89. 26	1.229 705 384	108	135. 13
.956 566 856	78	91. 59	1.245 092 256	110	138. 50
.977 035 936	80	94. 33	1.260 135 480	112	142. 42
.997 209 832	82	97. 8	1.274 777 184	114	146. 50

NUMER. APERT. n sin. u	BALS. A. n—1.52.	WATER A. n — 1.33.	NUMER. APERT. n sin. u	BALS. A. n—1.52.
1.289 031 592	116	151. 29	1.474 849 212	152
1.302 896 272	118	156. 50	1.481 044 072	154
1.316 359 520	120	163. 35	1.486 781 160	156
1.329 422 400	122	176. 38	1.492.073 496	158
1.342 083 392	124		1.496 906 336	160
1.354 329 272	126		1.501 286 672	162
1.366 166 576	128		1.505 207 664	164
1.377 588 616	130		1.508 669 160	166
1.388 586 576	132		1.511 671 160	168
1.399 166 536	134		1.514 213 664	170
1.409 321 352	136		1.516 300 168	172
1.419 042 816	138		1.517 915 472	174
1.428 334 120	140		1.519 074 168	176
1.437 186 448	142		1.519 766 680	178
1.445 605 880	144		1.520 000 000	180
1.453 582 688	146			
1.461 118 544	148			
1.468 208 784	150			

THE WORKING SESSION.

The session for exhibiting methods of work and microscopical research was held in LeGrand Rink on Euclid Avenue, cor. Kennard street, on Thursday afternoon, August 20, 1885, commencing at 2 o'clock, P. M., and continuing during the afternoon.

On December 29, 1884, the Executive Committee unanimously delegated to Mr. C. M. Vorce, of Cleveland, the work of organizing the Working Session and preparing for its demonstrations, and allotted to the working session one entire afternoon of the meeting as the utmost of time that could be spared for that especial purpose.

Mr. Vorce accepted the responsibility, and at once set about the preparations for the session. After correspondence with several members of the Society Mr. Vorce published in *The Microscope* for February, 1885, and in *The American Monthly Microscopical Journal* for March, 1885, a scheme of work which he had planned for the Working Session, and in the execution of which he solicited the assistance of members.

Demonstrators for nearly all the themes embraced in the published scheme of work were secured, but before the meeting convened several of the demonstrators found themselves prevented by various causes from attendance, and, after filling such vacancies as could be filled in the short time allowed, after the opening of the meeting the following demonstrations were presented:

SCHEDULE OF DEMONSTRATIONS.

Tables 3 and 4.

WM. H. WALMSLEY, F. R. M. S., - - - PHILADELPHIA, PA.

Photo-micrography by lamplight.

ROBERT DAYTON, M. D., - - - - - - - CLEVELAND, O.

Gelatino-bromide enlargement by lamplight, and photo-micrography by sunlight, in smoking-room, southeast corner of building.

Tables 5 and 6.

GEO. E. FELL, M. D., F. R. M. S., - - - - - BUFFALO, N. Y.

Methods of micrometry and U. S. standard micrometer, the standard for minute measurements, furnished by U. S. Bureau of Weights and Measures.

Tables 7 and 8.

W. H. BULLOCH, F. R. M. S., - - - - - - CHICAGO, ILL.

Comparator for testing and measuring micrometers, and method of testing, etc. Cob-web micrometer for measurements and steel standard with methods of measurement. Micrometer stage.

Tables 9 and 10.

C. M. VORCE, F. R. M. S., - - - - - - - CLEVELAND, O.

Secondary stage for micrometry of blood, etc., and method of measurement.

Tables 11 and 12.

T. J. BURRILL, Ph. D., F. R. M. S., - - - CHAMPAIGNE, ILL.

Cultivating Bacteria, etc., exposition of different methods and apparatus.

Tables 13 and 14.

A. H. TUTTLE, Ph. D., F. R. M. S., - - - - COLUMBUS, O.

Staining tissues in mass, simple and compound stainings.

Table 15.

L. M. EASTMAN, M. D., - - - - - - - - BALTIMORE, MD.

Staining sections, simple and compound stainings, animal sections.

Table 17.

GEO. DUFFIELD, M. D., - - - - - - - - DETROIT, MICH.

Cutting sections of soft tissues. Schanzi microtome.

Table 18.

H. E. SUMMERS, Cornell University, - - - - - ITHACA, N. Y.

Cutting serial sections (Prof. S. H. Gage's methods), Bauch and Lomb's New Microtome.

Table 19.

E. H. SARGENT, Cornell University, - - - - ITHACA, N. Y.

Imbedding in celloidin and cutting sections in celloidin. Bausch and Lomb's New Microtome.

Table 20.

LESTER CURTIS, M. D., F. R. M. S., - - - - - CHICAGO, ILL.

Section cutting with Bulloch's New Microtome.

Tables 21 and 22.

F. O. JACOBS, M. D., D. D. S., - - - - - - NEWARK, O.

Section cutting with Jacobs' New Freezing Microtome. Cutting sections of teeth, etc.

Table 23.

ALLAN Y. MOORE, M. D. - - - - - - - CLEVELAND, O.

Practical demonstration of the relation of aperture to power in microscope objectives.

Table 24.

F. S. NEWCOMER, M. D., - - - - - - INDIANAPOLIS, IND.

Uses of the mechanical finger, application to research, etc.

Table 26.

S. M. MOSGROVE, M. D., . - - - - - . . URBANA, O.

Application of electric light to microscopy.

Table 27.

D. S. KELLICOTT, Ph. D., F. R. M. S. - - - BUFFALO, N. Y.

Uses of life boxes, growing cells, troughs, compressors, etc.

Table 28.

S. HUDSON, M. D., - - - - - - - - - - MEDINA, O.

Urine and pus.

Table 29.

HENRY MILLS, - - - - - - - - - - BUFFALO, N. Y.

Preparing and mounting sponges.

Table 30.

R. N. REYNOLDS, - - - - - - - - - DETROIT, MICH.

Staining and mounting Bacteria.

Table 31.

THOS. TAYLOR, M. D., - - - - - - WASHINGTON, D. C.

Examining butter and fats.

Tables 33 and 34.

FRANK L. JAMES, Ph. D., M. D., - - - ST. LOUIS, MO.

The preparation and application of cements, formulas, etc.

Table 35.

C. WELLINGTON, - - - - - - - - - JACKSON, MICH.

Mounting vegetable sections.

Table 36.

E. H. GRIFFITH, A. M., F. R. M. S., - - - FAIRPORT, N. Y.

Finishing slides.

Table 37.

FRANK F. COLWELL, - - - - - - - - URBANA, O.

Mounting and finishing slides.

Table 38.

J. O. STILLSON, M. D., - - - - - - - INDIANAPOLIS, IND.

Mounting and finishing slides and general microscopical work.

EXHIBIT OF SPECIAL APPARATUS.

Table space was provided on the north side of the hall at which exhibits of instruments, accessories and apparatus were made by The Bausch & Lomb Optical Company, Messrs. J. W. Queen & Co., Messrs. W. H. Walmsley & Co., W. H. Bulloch, Messrs. F. J. Emmerich & Co., The Geneva Optical Co., C. E. Hanaman, Esq. Special apparatus was also exhibited by several of the demonstrators on the tables occupied by them in the Working Session.

PHOTOGRAPHIC EXHIBIT.

Photo-micrographs exhibited by the following-named persons were arranged upon large cards and displayed upon the walls:

R. L. MADDOX, M. D., F. R. M. S., London, Eng.
DR. HENRI VAN HEURCK, Director Botanical Garden, Antwerp.
PROF. H. L. SMITH, F. R. M. S., Geneva, N. Y., Photographs by Dr. J. J. Woodward, etc.
MAJ. GEO. M. STERNBERG, M. D., U. S. A., Washington, D. C.
GEO. A. PIERSOL, M. D., Philadelphia, Pa.
W. H. WALMSLEY, F. R. M. S., Philadelphia, Pa.
CHRISTIAN FEBIGER, Esq., Wilmington, Del.
HON. J. D. COX, F. R. M. S., Cincinnati, O.
J. L. SMITH, New York City.
P. H. DUDLEY, New York City.
A. G. HOEHN, M. D., Baltimore, Md.
REV. ED. HUBER, Baltimore, Md.
ROB'T DAYTON, M. D, Cleveland, O.
C. M. VORCE, F. R. M. S., Cleveland, O.
H. J. DETMERS, M. D., Champaigne, Ill.
Prof. C. RICHARDSON, Washington, D. C.

The photographs were accompanied by memoranda as to power and objectives used, light employed, time of exposure, kind of plate and developer used, etc., and proved of great service to those not fully versed in the art of photo-micrography.

Miss M. A. Booth distributed to the members present samples of Atlantic coast diatoms procured and prepared by herself, and Mr. Vorce distributed samples of Mobile Bay diatoms forwarded to him for that purpose by Dr. Geo. H. Taylor of Mobile, Ala., and samples of diatomaceous earth from Denver, Col., forwarded by H. B. Chamberlin, Esq., of Denver.

Dr. Taylor furnished the following description of the method by which the samples he furnished were prepared:

WATERWASHED DIATOMS.

DR. GEO. H. TAYLOR'S METHOD.

A quantity of the mud containing the diatoms is placed in a large jar with two or three times its bulk of clean water and thoroughly shaken up. After settling for ten minutes about half the water is poured off into another jar, and the first is refilled, shaken, allowed to settle as before, and most of the water poured off. This process is kept up until the water is perfectly clear at the end of ten minutes. The light portions poured off are saved for future treatment.

The heavy material which contains all but the smallest diatoms, has much sand mixed with it. To get rid of this it is shaken up in the jar of water, and the top part almost immediately poured off. This is repeated several times, refilling the jar with pure water each time until the heavy sand remaining shows but few diatoms mixed with it. The material obtained by the last pourings, consisting of nearly all the diatoms, and the *fine* sand is now boiled in water with the addition of a little cooking soda. After which it is placed in a large bottle filled with pure water, shaken up, and after standing five minutes poured off. The bottle is refilled and the process continued for several hours, the time of settling being gradually reduced to three, or even two minutes. The remaining material is then placed in a shallow concave dish, a little at a time, with a small amount of water, and gently rocked and rotated, by which the diatoms

and lighter particles rise in the water, and can either be poured off or dipped out with a pipette, leaving most of the sand behind.

The material so obtained is called "waterwashed," as no acids are used, and almost the whole treatment is with pure water alone.

For perfect cleaning of the material Dr. Taylor furnishes the following directions:

CLEANING DIATOMS FROM MARINE MUDS.

DR. GEO. H. TAYLOR'S PROCESS.

A quantity of the mud found to contain diatoms is placed in a large jar, which is then filled with clean water, thoroughly shaken, and allowed to settle for ten minutes. One-half is then poured off into another jar, the first refilled, shaken up, and again allowed to settle for ten minutes when the top portion is poured off into a third jar. The heavier material in the first jar is now washed several times by filling the jar with clean water, thoroughly shaking, settling for ten minutes and pouring off the top portion into the third jar. This process is continued with the first jar until the water is clear after settling for ten minutes. The material is then taken from the first jar in small quantities and "sanded" by placing each portion in a shallow dish with a moderate quantity of water, and rotating the dish so as to cause a vortex in the water, when the diatoms and lighter matter will rise in the water and can be poured off into a quart bottle, leaving the sand and heavier particles behind. This process is repeated with each portion until only sand is left in the dish, which sand is, of course, thrown away. The "sanded" material accumulated in the quart bottle is now placed in an evaporating dish, holding at least half a pint, and dried. When dry, nitric acid is poured upon it in liberal quantity, and it is boiled until fumes cease to appear, when a few grains of bichromate of potash are dropped in, and after boiling a few minutes more the dish and its contents are allowed to cool. When cool, pour off the acid and refill the dish with sulphuric acid; boil this thoroughly, and finally add a little bichromate of potash. It is better to pour off the acid and add fresh, at least once during the boiling, or to drop in a quantity of fresh acid several times during the boiling, which can scarcely be too prolonged. When the sul-

phuric acid has thoroughly cooled it is poured off, but *not into water*, and the material in the dish is washed two or three times with clean water, stirring it up well on the addition of each supply, and allowing it to settle each time before decanting. It is now again sanded by rotating the dish and pouring off the top portion of the fluid into the quart bottle, adding more water each time, until only sand is left in the dish. The material in the bottle, now rich in diatoms, is shaken up, allowed to settle and the water poured off, until every trace of acid is removed, when the material is returned to the clean evaporating dish which is nearly filled with water, placed over the lamp and the water brought to a boil. A very small piece, not over one-half inch in length, of caustic potash, is now added and the boiling continued for two or three minutes (too long boiling will destroy the diatoms), when the contents of the dish are poured into the quart bottle, which is kept ready about half filled with cold water. The material is now again washed by shaking, settling for five minutes, and pouring off most of the water, repeating the operation with fresh quantities of clean water and decreasing the period of settling to two or three minutes, until the water is free from any trace of alkali. The material is now again sanded in small quantities at a time in one of the square convex glasses used for photochrome pictures, by gently agitating and rotating the glass and drawing of the lighter portion from one corner of the glass by means of a dropping tube. The material withdrawn is dropped into a small vial and contains almost all the diatoms; sand and vegetable silica only remaining in the glass at the last. Fresh water is added frequently to replace what is withdrawn.

When all the material has been through this process and is accumulated in the small vial, it is, although vastly reduced in bulk, extremely rich, containing but little sand and a small amount of vegetable silica. It would be considered by most persons well-cleaned material, but a little more time and labor will greatly improve it. Wash the material several times in *distilled* water if it can be had, if not, in filtered rain water, or the purest water to be obtained. And great care must now be used to exclude floating fibers and dust; about five or seven minutes should be allowed for settling. Add now about twenty drops of ammonia, shake well,

and continue the washing as before. It is better to wash ten times than only two or three times, as each shaking loosens a kind of flocculent matter which comes away in the washings. Another sanding in a smaller convex glass with distilled water will improve the material, and if persisted in will give you entirely pure diatoms free from foreign matter or sand. Care should be used not to overlook and throw away the large forms of diatoms which often adhere obstinately to the glass. Frequent examination of samples will direct the steps of the process and show when a perfect result is obtained. The material in jars 2 and 3 can be put through the same process and will yield smaller forms. The sand and large diatoms which cannot be separated from it by the above process may also be saved and the diatoms picked out separately under a lens or by means of a mechanical finger. Only unlimited patience will ensure the best results.

LIST OF MOBILE BAY DIATOMS.

By J. D. Cox, LL. D., Cincinnati, O.

Actinocyclus Ehrenbergii, Ralfs.
" fuscus, Norman (*dubius* Grunow).
Actinoptychus undulatus, Ehr.
" areolatus, Ehr.
" splendens, Ralfs.
" trifoliatus, McNeill, N. Sp.*
Amphora proteus, Gregory.
" Clevei, Grunow.
" cingulata, Cleve.
" obtusa, Greg. and H. L. Sm.
Amphiprora elegans, W. Sm.
" vitrea, W. Sm.
Amphiprora costata.
" alata, Kutz'g.
" lepidoptera, Greg.
Asteromphalus Brookii, Bailey.
Auliscus sculptus, Ralfs.
" cælatus, Bailey.
" pruinosus, Bailey.
Auliscus radiatus, Bailey.
" punctatus, Bailey.
Amphitetras antediluviana, Ehr.
Bacteriastrum curvatum, Shadbolt.
Biddulphia rhombus, W. Sm.
" Baileyi, W. Sm.

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* This new species described by Mr. W. S. McNeill of Mobile, I have found in the Richmond and Petersburg fossil deposits, and have been informed by Mr. C. L. Peticolas, of Richmond, that he has found and noted it in the same earth. Mr. McNeill describes and figures it as follows: Disc considerably convex, with three depressions, broadly heart-shaped, shallow, like a broad trefoil; opposite each of the narrower ridges separating the trefoil leaves is a spine within the rim of the disc. Aerolation sub-hexagonal or irregularly reticulate with finer system of regular punctæ, similar to that of the more finely marked *Actinoptychus areolatus*, Ehr. Hoop hyaline—the trefoil leaves not bounded by sharp depression, but passing into the intervening ridges by very gradual curve.

Biddulphia aurita, Bréb.
" lævis, W. Sm.
Cerataulus turgidus, Ehr.
" Smithii, Bréb.
Campylodiscus clypeus, Ehr.
" echineis, Ehr.
" limbatus, Bréb.
" Samoensis, Grun.
" ecclesianus, Grev.
Chætoceros distans, Cleve.
Coconema lanceolatum, Ehr.
Coscinodiscus nitidus, Gregory.
" radiatus, Ehr.
" subtilis, Ehr.
" lineatus, Ehr.
" excentricus, Ehr.
Cymatopleura elliptica, Bréb.
Cymbella heteropleura, Ehr.
Epithemia zebra, Kutz'g.
Eunotia Arcus, Ehr.
" parallela, Ehr.
" diodon, Ehr.
" triodon, Ehr.
Eupodiscus Argus, Ehr.
" radiatus, Bailey.
Grammatophora marina, W. Sm.
Navicula lyra (type) Ehr.
" lyra, var. recta.
" " var. elliptica.
" " var. dilatata.
" irrorata, Greville.
" permagna, Bailey.
" maculata, Edwards.
" Caribbea, Cleve.
" didyma, Kutz'g.
" marginata, Lewis.
" Hennedyi, W. Sm.
" prætexta, Ehr.
" Lewisiana, Grev.
" serratula, Grunow.
Navicula ovalis, Ehr.
" humerosa, Ehr.
" humerosa, Bréb.
" maculata, W. Sm.
" ?(Schmidt's atlas, pl. 45, fig. 13), N. Sp.
Nitzschia circumsuta, Bailey.
" scalaris, Ehr.
" sigmoidea, W. Sm.
" sigma, W. Sm., var. *elongata*, Grunow.
Orthosira marina, W. Sm.
Pinularia distans, W. Sm.
" longa, Gregory.
" major, Rabh.
" nobilis, Ehr.
Plagiogramma Gregorianum, Grev.
" validum, Grev.
Pleurosigma formosum, W. Sm.
" decorum, W. Sm.
" angulatum, W. Sm.
" æstuarii, W. Sm.
" acuminatum, W. Sm.
" balticum, W. Sm.
Raphoneis amphiceros, Kutz'g.
Rhabdonema arcuatum, Kutz'g.
Stauroneis Phœnicenteron, Ehr.
" pulchella, W. Sm.
Surirella Febigerii, Lewis.
" fastuosa, Ehr.
" Davidsonii, A Schmidt.
" splendida, Kutz'g.
Systephania diadema, Ehr.
Terpsinoe musica, Ehr.
" Americana, Bailey.
Triblyonella punctata, W. Sm.
Triceratium favus, Ehr.
" alternans, Ehr.
" sculptum, Shadbolt.

The foregoing list of species is not furnished as a complete list of forms to be found in the material, but merely those forms thus far identified by the author.

REPORTS.

REPORT OF COMMITTEE ON STANDARD MICROMETER.

To the American Society of Microscopists:

The year ending with the meeting at Cleveland, August, 1885, has been marked with but little progress in the work of obtaining copies of the Standard for general use among microscopists.

At the Rochester meeting the reports of the comparisons with the Standard of one of the copies made by Mr. Fasoldt, by Professors Rogers and Anthony, was given in detail to the Society (see Rochester Proceedings, p 221). The experience with this copy has resulted in the actual demonstration of what was held as the opinion of some of the members of the committee, *that all standards should be made of material less liable to destruction than thin glass*, upon which Mr. Fasoldt had ruled his copies. Within a short time after the Rochester meeting, Mr. W. H. Bulloch, of Chicago, requested the copy referred to above, for the purpose of making a series of comparisons with some new micrometric apparatus he had prepared. Acting within instructions the custodian forwarded the copy to Mr. Bulloch, taking his receipt for the same with the assurance that the copy or its money equivalent, in event of breakage, would be returned to the hands of the custodian.

Before long the custodian was informed that the copy had been ruined by an objective passing through it.

At Cleveland Mr. Bulloch informed the committee that he had instructed Mr. Fasoldt to prepare another copy to replace the one destroyed, and with which he proposed to reimburse the Society.

He was requested to annul the order, as the copy would be valueless to the Society unless made the subject of comparison with the Standard by known experts.

During the year the Standard has been retained in the possession of the custodian. Application will be made, it is understood, for permission to place it in the hands of Prof. Marshall D. Ewell, of

Chicago, who will continue the comparisons and verify those made by Profs. Rogers and Hilgard (see Chicago Proceedings, pp. 181, 184).

On the completion of this work by Prof. Ewell, Prof. Rogers has consented to prepare a series of copies of the Standard on thick plate glass, or other suitable material, in time for the meeting of the Society at Chautauqua.

At the Cleveland meeting, on motion of Dr. Fell, Dr. R. H. Ward, of Troy, was added to the Committee on Micrometry.

ALBERT McCALLA,
LESTER CURTIS,
R. H. WARD,
GEO. E. FELL,
Committee.

REPORT OF TREASURER AND CUSTODIAN.

CLEVELAND, Ohio, August 21, 1885.

RECEIPTS, AUG. 22, 1884, TO AUG. 18, 1885.

Cash on hand August 22, 1884	$380.73	
Received from sale of Publications	52.10	
Admission Fees and Dues	386.50	
Total		$819.33

DISBURSEMENTS, AUG. 22, 1884, TO AUG. 18, 1885.

Postage, Circulars, Stationery, etc.	$ 94.88	
Cost of Proceedings	626.09	
Total		720.97
Cash on hand August 18, 1885		$ 98.36
Receipts at Cleveland from sale of Publications, Fees and Dues		343.90
		$442.26
Disbursements at Cleveland		34.61
Cash on hand August 23, 1885		$407.65

ASSETS.

Dues and Admission Fees, unpaid	374.00
Cash in Secretary's hands	30.00
Possible Available Funds	$811.65

GEO. E. FELL,
Treasurer and Custodian.

REPORT OF AUDITORS.

CLEVELAND, Ohio, August 23, 1885.

WE beg leave to report that we have carefully examined the books and vouchers of the Treasurer for the year ending August 21, 1885, and have found the same to be correct.

H. F. ATWOOD,
CHAS. H. STOWELL,
Auditing Committee.

LIST OF SLIDES.

[*For rules governing the custody and circulation of these slides see the minutes of Friday p. m. session.*]

Capsella bursa-pastoris (1). Ovaries in various stages of development.

Cereus grandiflora (2). Transection of the ovary.

——— ———— (3). Transection near the base of the style.

——— ———— (4). Ovules and stigma with pollentubes.

Cibotium regale (16–23). Eight sections illustrating Mr. Kruttschnitt's paper on the development of ferns. (See Proc. Chicago meeting, p. 135).

Cristatella ophidiodea (24). Statoblast, from Niagara river.

Crustacea (30–32).

Cuphea (5). Ovary.

Dry mounts (27–29). A. H. Chester's method. (See Proc. Chicago meeting, p. 143).

Epistylis ophidioidea (26). (See p. 39 and *The Microscope*, IV., 248).

Ferns, their development, Eight slides illustrating (16–24). (See Proc. Chicago meeting, p. 135).

Gold (27). Crystals, fern-leaf form.

—— (28). Crystals, prismatic form.

—— (29). Native, and petzite.

Infusoria (25, 26, 33).

Leptodora hyalina (30, 31, male; 32, female). From Mr. T. Clarke, Birmingham, Eng.

Monotropa uniflora (6). Section of the ovary.

Oenothera biennis (7). Section of the ovary.

——— ——— (8). Stigma, with pollengrains and pollentubes.

Opercularia rugosa (33). (See Proc. Rochester meeting, p. 119).

Papaver somniferum (9). Transection of the ovary.

Pectinatella magnifica (34). Statoblast, Niagara river.

Plumatella orbisperma (35). Statoblasts. (See Proc. Elmira meeting, p. 227).

Plumatella vitrea (36). Statoblasts, Niagara river.

Pollentubes (1–15). Sections of various ovaries illustrating Mr. Kruttschnitt's views. (See Proc. Rochester meeting, p. 93, and of Cleveland meeting, p. 63), viz.:

1. Capsella Bursa-pastoris—ovaries in various stages of development.
2. Cereus grandiflora—transverse section of ovary.
3. Cereus grandiflora—transverse section near base of style.
4. Cereus grandiflora—ovules and stigma with pollentubes.
5. Cuphea (Lythraceæ)—ovary.
6. Monotropa uniflora—transverse and longitudinal sections of ovary.
7. Oenothera biennis—sections of ovary.
8. Oenothera biennis—stigma with pollengrains and tubes.
9. Papaver somniferum—transverse section of ovary.
10. Portulacca, section of ovary.
11. Portulacca oleracea—stigma with pollentubes.
12. Pyrola elliptica—ovules.
13. Trifolium pratense—ovary, stlye and stigma, united.
14. Zinnia (Compositæ)—flower with ovary.
15. Zinnia (Compositæ)—flower with ovary.

These preparations are put up in camphor and chloroform water after having been cleared in caustic soda, and bleached in chlorinated soda—stained with violet aniline and Bismarck brown.

Polyzoa (24, 34, 35, 36).

Portulacca oleracea (10). Section of ovary.

——— ——— (11). Section of stigma with pollentubes.

Pyrola elliptica (12). Ovules.

Stylohedra lenticula (25). (See Proceedings Rochester meeting, p. 122).

Statoblasts of Polyzoa (24, 34, 35, 36).

Trichina spiralis (37). In human muscle, encysted and free.

Trifolium pratense (13). Ovary, style and stigma.

Zinnia (14, 15). Flower with ovary.

The Necrology.

MEMOIR OF THAD S. UP DE GRAFF, M. D., F. R. M. S.

I feel highly honored by my selection by this Society as a proper person to prepare a memoir of my friend, the late Doctor Up de Graff; and, if my memoir shall be open to the criticism of reading more like an eulogy than an impartial history, I can only plead that, much as I admired his brilliant mental gifts and his marvelous deftness of hand, I loved him still more for those qualities of the heart which made him an object of affection to all who were brought into intimate contact with him.

Thad Stevens Up de Graff was born in Harrisburg, Pa., April 12, 1839. His father was a distinguished surgeon of eccentric habits and great mechanical genius, but unfortunately a slave to the opium habit. From him the subject of this memoir inherited his genius and an extremely sensitive, nervous organization; and from his mother, who is still living, a slender and delicate, yet powerful frame.

While a lad he attended Dr. Fisher's Seminary, at Selin's Grove, and afterward spent five years in the study of medicine, receiving his diploma from the St. Louis (Mo.), Medical College in 1859; he also pursued a special course in chemistry and mineralogy at the

University of Michigan. He has, at rare intervals, told me a little of the struggles and trials of his youth; how he did menial service during his attendance at medical college to get board and lodging; how, after his graduation, he went on the railroad as far as his money would take him, and brought up in an Indiana town, moneyless, friendless and unknown; how fortune smiled on him, success attended his practice, and money began to come in; and how, best of all, he wooed and won Miss Ella A. Hale, of Indianapolis, and married her on the 1st day of December, 1859—"and lived happy ever after," as the old stories put it.

Shortly before the War of the Rebellion broke out, he moved to Olney, Illinois. He was a war democrat, and chanced to be at the house of the democratic candidate for Governor of Illinois when that gentleman received the news of his nomination, and, at his request, the Doctor introduced him to the crowd who came to serenade him on the occasion. This made the Doctor somewhat well known as a democrat, and, when it became necessary for speakers to go into Southern Illinois to strive to awaken Union sentiments, the Doctor was selected as one of them, for the climate of that section (Egypt, as it was called) was not, at that time, healthy for republicans. So well did he succeed that not only were his Union sentiments tolerated, but he awakened the latent patriotism of many of his hearers and a company of volunteers was raised and he was elected Captain. Assigned to the Twenty-sixth Regiment of Illinois Volunteers, Captain Up de Graff and his company took part in many battles. He was wounded at the battle of Mill Spring, Kentucky, and was afterwards obliged to resign on account of ill health. When he recovered sufficiently, he resumed the practice of his profession in Vincennes, Indiana, and shortly after moved to Elmira, N. Y.

Here his genial manner soon won him friends and his skill brought him patients, and his offices in the Rathbun block were enlarged from time to time till they were very complete. Unfortunately they were completely destroyed by fire and with them a remarkable collection of surgical instruments and appliances—many of them of his own invention—together with valuable cabinets of anatomical, pathological and other specimens, and many of the records of his practice. The offices were rebuilt and refitted, but

soon proved too small, and in 1873 he moved across the river and opened the Elmira Surgical Institute—a private hospital where most of his subsequent work was done. He has often spoken to me of this as one of the wisest steps of his life; the more complete control and supervision which he was thus enabled to exercise over his patients while under treatment being, in his opinion, a most important factor in his success. This hospital was usually full to overflowing; but few save himself and his beneficiaries knew how many of the deserving poor received there not only skillful treatment, but board and lodging gratis, till they were able to go upon their way rejoicing. No one could ever guess by his manner at clinic hour which were the pay-patients and which the ones to whom all was free.

His specialty was surgery, and more particularly that of the eye and ear,—he had operated for cataract over six hundred times. Here, the delicacy of his touch, his remarkable finger skill and his surgical courage served him well, and he usually operated for cataract without anæsthesia and without the use of the fixation forceps. He was also remarkably skillful and successful in general surgery, having operated for ovariotomy twenty-two times, tied the common carotid and common iliac arteries, made several successful amputations at the thigh, and, indeed, made most if not all of the major operations, besides innumerable smaller ones.

His mechanical genius often led him to the invention of new forms of surgical instruments,—sometimes valuable improvements for general use, often skillful modifications of existing instruments to adapt them to some peculiar case,—but all exhibiting that neatness of design and execution which characterized all his work.

I first became acquainted with Doctor Up de Graff in 1879, through the agency of our mutual friend Dr. S. O. Gleason. I shall never forget the impression he made upon me. I had called on Dr. Gleason, whom I knew through correspondence on matters microscopical, and he suggested to me that we both go over the river and see Dr. Up de Graff, as he also was interested in the microscope.

When we stopped in front of the Elmira Surgical Institute, a remarkable-looking little man came out to meet us. He was not, I think, more than five feet five or six inches high, slender, but lithe

and agile in body, with a rather large, finely-shaped head set firmly on his sloping shoulders, long straight black hair combed back from a high white forehead and falling well down on the neck; bright, piercing eyes deeply set under the overhanging brows—a large aquiline nose, delicately-cut, sensitive mouth, partly hidden by the flowing moustache, and the lower part of the face entirely hidden by a long, pointed dark beard. He wore an ordinary business suit, except the coat which he had replaced with his laboratory jacket of velvet. I noted the extreme delicacy of his hands, the bright clearness of his voice and manner, and the cordiality with which he received me as if I had been an old friend. We went directly into his private office and began to talk microscope at once. He had just received about a dozen objectives of some inferior foreign make sent him by some New York optician for examination. I was asked my opinion and gave it, softening it a little, and so was led to air my then unpopular heresy in reference to lenses of wide aperture. We stayed to tea and I enjoyed the visit immensely. After a time I visited Elmira again and called on Dr. Up de Graff, and he insisted on my staying to tea, wanted me to stay all night, "Why not spend a week with me?" Next time I saw him I was on sick leave; was going to New York for medical advice, and stopped over in Elmira to see a sister who was teaching there. I went to the Institute to call on Dr. Up de Graff, intending to continue my journey the same night, but this he would not hear of; I must stay all night and get rested. It finally resulted in my staying three weeks, enjoying the doctor's hospitality, receiving the benefit of his skill, and becoming acquainted with his charming family; and from that day till the present I have been more like a member of that family than a stranger. The family then consisted of the doctor and his charming wife, his eldest son Thad, then a student of medicine and now his father's worthy successor; a second boy, Way, about sixteen, I think, rather sedate and a born surgeon; Fritz, the youngest boy—boy all over—and two dear little girls, Kate and Alice, the latter, the baby of the family, very pretty and very affectionate, was so suggestive of a nice little white kitten that she was generally known as "Puss"; there was also a young lady niece of Mrs. Up de Graff's, Miss Gibbs.

Into this family I was received on familiar terms. I was equally welcomed into the doctor's laboratory, his operating room, his private office, and into the parlor and nursery of his residence. Thus I had opportunity to see him in all aspects, as an investigator, as a surgeon, as a father, and as a friend. And it is something for me to be able to say now, that having seen him thus frequently and intimately, I can recall no word or deed of his that standing by his grave I would care to blot out. Naturally quick-tempered and impulsive, the warmth of his affections kept his temper from becoming unpleasant. Hospitable and generous to a fault, fond of good living and good company, he delighted to see his table filled with the good things of the earth and surrounded by friends.

He was, I think, the most versatile man I ever knew. He seemed able to do anything he chose to undertake, and to do it well. As an operator upon the eye he was most dextrous—as the fact that he usually operated for cataract without anæsthesia and without fixation is sufficient to prove,—as a general surgeon his practice was characterized by a bold prudence and a degree of mechanical skill in planning and executing difficult operations seldom equalled. He took up oil-painting for a pastime, once, and soon got beyond the range of ordinary amateur work; he was a good carpenter, as many bits of work about his Institute remain to prove; an enthusiastic fly-fisher; it was his custom to spend a month of each year on the banks of the Lycoming in his favorite pursuit, and in communion with Nature. He embodied the results of his experience in camp in a book called " Bodines, " full of wit, humor, natural history and shrewd philosophy. I have seen the original manuscript as sent to publishers, and it is most beautifully and legibly written, on commercial note paper, without scratch or blot, and I am not surprised that the publishers stated that they had never seen such a MS. before and never expected to see such another. He was an excellent amateur photographer, both with the ordinary camera and with the microscope.

In preparing and mounting microscopical specimens he had few, if any, superiors in this country or, of course, elsewhere; he was possessed of great executive ability, and was the life of the Elmira Microscopical Society; and it was due largely to his exertions and

abilities as chairman of the local committee that the Elmira meeting of the A. S. M. became the success it was, and the turning-point in the history of this organization. As our worthy Treasurer, Prof. Fell, truly stated, "The A. S. M., at Columbus, was in a fair way to fulfill the predictions of its enemies till Drs. Gleason and Up de Graff appeared on the scene and extended their hearty invitation to go to Elmira." I was elected President, and Dr. Up de Graff one of the Vice-Presidents, and, though I worked hard and was ably assisted by Profs. Kellicott and Fell as Secretary and Treasurer, I doubt that success would have crowned our efforts but for the work done by Dr. Up de Graff. He secured the splendid Park Church for our meetings, got prominent citizens to throw open their doors and receive our members as their guests, secured the attendance of prominent microscopists, who knew little of our young society and came only on his urgent invitation. He looked after every detail, kept the sub-committees up to their work, and contributed, I honestly believe, more than any other one person to the success of that meeting, upon which the existence of this Society depended.

He was always willing to work hard for what he believed to be a good cause, and was careless as to who got the credit due to him. He was just, generous, affectionate and talented, and he had but one prominent fault, viz., intemperance. I do not mean that he was a drunkard, for he was nothing of the kind, but he lacked moderation. Delicate and sensitive as he was, he would sit up all night over his microscope trying to unravel some biological puzzle, and be prostrated next day with one of his terrible headaches as a consequence. In the pursuit of science, in the invention of a new surgical instrument or operation, or even in the elaboration of some whim, he never spared himself, but would go practically without food or sleep till his end was attained. In this way he accomplished much, but shortened a life that might have been prolonged for years.

The last year or so of his life was spent in weakness and suffering; the headaches from which he had suffered from boyhood increased in severity and frequency till he was often completely prostrated by them for days at a time, and was seldom, if ever, entirely free from cephalic pain ; albumen appeared in his urine, and finally at noon on the third day of August, 1885, he died calmly, peacefully, and without a struggle.

The eager, restless spirit, the keen, active intellect, the warm, impulsive, loving heart had outworn the slight, delicate body, and he died worn out ere he had reached fifty years of age. Counted by years the life was a short one; measured by deeds it was a long one. A home had been founded, a family reared, his eldest son prepared to step into his place; knowledge had been acquired, a reputation made, more than six hundred operations for cataract, twenty-two ovariotomies, the common carotid and the iliac arteries had been tied successfully, new instruments and new operatons invented, and a host of the more ordinary surgical operations performed. He had won success as a physician, as a surgeon, as a microscopist, and photographer, as an author and as a public speaker; he had been up in a balloon, and down in a mine; the woods, the streams and the ocean had yielded up secret after secret to him. Honors had been thrust upon him in the various branches of the Masonic order; he had served his country on the field of battle; and, in civil life, he had been made a Fellow of the Royal Microscopical Society of England, member and Vice-President of the American Society of Microscopists; had made a few enemies and hosts of friends. He was a good lover but not a good hater; he had less of bitterness in his nature than seemed possible with so decided a character. His faults were few, his virtues many. May we not hope that the restless spirit has found rest, and that in wider, fuller knowledge, with eternity before him, he learns that patience which seemed to be the only virtue he could not acquire here.—GEO. E. BLACKHAM.

JAS. N. SCATCHERD.

The second meeting of the American Society of Microscopists was, in some respects, the most successful and most remarkable of any yet held. Marked by much enthusiasm on the part of the members, who were comparatively few in number, a great portion of the successful features must be accredited to the activity and careful preparatory work of the local committee at Buffalo. Among the members of this committee the late Mr. Jas. N. Scatcherd was one of the foremost in working for the interest of the Society. Notwithstanding the care of his large business interests, he devoted considerable time to systematizing the labors of the committee; almost

every railroad in the country was communicated with, and the work was commensurate with the meeting of a society numbering thousands instead of barely hundreds. It was but characteristic of the man. Whatever he undertook was certain to be thoroughly executed; his successful business career as a lumber merchant indicated this. Honest, upright in all his dealings, beloved by all with whom he came in contact, his death saddened many hearts. His generosity was always guided by sound judgment; he was ever ready to aid those who needed and deserved assistance, and his gifts were many.

At the time of his death he was a member of the Merchants' Exchange, a Director of the Third National Bank of Buffalo, Chairman of the Board of Trustees of the Delaware Ave. Methodist Church, President of the Buffalo General Hospital Association, and Chairman of the Buffalo Board of Water Commissioners.

He was not an active member of the American Society of Microscopists, but faithfully supported it, believing it to be a commendable enterprise and one that deserved the support of all interested in the advance of science in America.

He died at his residence, in Buffalo, January 18, 1885, and was buried at Forest Lawn Cemetery at Buffalo.—GEO. E. FELL.

PROCEEDINGS

OF THE

AMERICAN SOCIETY OF MICROSCOPISTS.

MINUTES OF THE EIGHTH ANNUAL MEETING.

The Eighth Annual Meeting of the Society was held in Cleveland, O., August 18, 19, 20 and 21, 1885.

TUESDAY, August 18, A. M. Session.

The meeting was called to order by Mr. C. M. Vorce of the Cleveland Microscopical Society, at 10.30 A. M., in the new Court-house. Mr. Vorce addressed the Society:

"It is literally true that words are inadequate to express the gratification that the members of the Cleveland Society experience in being at last permitted to welcome your coming to this city as our guests. It is an event that we have for years looked forward to with very bright and hopeful anticipations.

"The pleasure of making the acquaintance of so many gentlemen not only in our own pursuit but in other branches of science and attracting them to our city has since the first formation of this Society been the subject of frequent and earnest consideration by the microscopists of Cleveland, but there have been difficulties in the way which we have not found it easy to overcome, and circumstances have seemed to counsel delay. So, with what patience we could, we have waited all these years, hoping always soon to realize the consummation of our wishes and trusting to oft-repeated assurances that soon a favorable opportunity would offer to invite you to our city. But with all our waiting there has been practically no change in circumstances, and it seemed to us useless to wait longer, and last fall we concluded to invite you to meet with us this year although the facilities we could offer you might not be all that you could wish. While the Forest City offers innumerable attractions and inducements for visitors to sojourn with us, it is singularly wanting in buildings containing halls suitable for a convention of this kind, although several fine new buildings are just approaching completion which are admirably adapted for such purposes, and some of which that have been in progress for years we had hoped would be completed in time for this meeting. But inadequate as are the facilities we can offer in the way of meeting halls, etc., our hearts

are enlisted in the cause and objects of your meeting, our interest in your proceedings will be found unfailing, and I can assure you we could not give you a warmer or more heartfelt welcome if we were able to offer you a palace for your meeting place. We feel sure that your coming among us and the holding of your meeting here will stimulate in this community the love for scientific research and will widen the field for usefulness of our own local society.

"From the responses we have received from members and others interested in microscopy, we have every reason to anticipate a large attendance, a gathering of more than usual interest and the accomplishment of valuable results, which will add luster to your society. I take pleasure in introducing to you Hon. George W. Gardner, the Mayor of our city, who will express to you the sentiments of our citizens regarding your meeting."

Mr. Vorce then introduced Hon. George W. Gardner, Mayor of the city, who cordially welcomed the Society in behalf of the citizens of Cleveland. In the course of his remarks he said:

"As a citizen of Cleveland I can assure you that I take pride in extending to you a hearty welcome to our city. I take great pride in the fact that such a large representation of men of high intelligence has selected this city for the place of its annual meeting. As chief executive of the city I express the honor which I believe we all feel in the fact that you have made such a selection; and, in behalf of the city, I extend to you a hearty welcome, and assure you that we will do all in our power to make this meeting as pleasant and profitable as we can. I hope your meeting will be productive of good results, and I entertain no doubt that matters of great magnitude to science and to mankind will be the outgrowth of your deliberations."

To this address President Hamilton L. Smith responded, on behalf of the Society, as follows:

"In the name of the American Society of Microscopists, I thank you, Mr. Mayor, for the words of welcome which you have given to us in behalf of the citizens of Cleveland. When your beautiful city was named as the place for our next meeting, we felt assured of a cordial welcome, for along the whole line of these great inland lakes, at once the glory and pride of our country, from the farthest shores of Superior to where Ontario's waters sparkle in the sunlight around the Thousand Isles, no more beautiful place than the Forest City can be found; certainly none with larger commercial enterprises, or greater art and science industries. We come to you, sir, not as noisy politicians, greedy for office, under the name of civil service reform, nor as theologians, endeavoring to settle some shade of doctrine,—we come as simple science students searching for truth, for the love of truth; and though our studies are confined to the investigation of the minute objects of nature, we believe that in the minute things the Creator is greatest, and that every addition to our knowledge of the working of natural laws, especially as

manifested in the minute world, will be a powerful factor of the new civilization. As for myself, sir, I lack words to express the thoughts that are pressing for utterance. Fifty years ago, less three, I came to this beautiful city; at that time the palatial hotel was the American, with its genial host, Philo Scoville. My destination was westward, across the pontoon bridge which then spanned the Crooked river, near where now is your noble viaduct. I climbed the hill to Ohio City, whose inhabitants then proudly prophesied that soon Cleveland would be eclipsed by their prosperous city—a prediction more nearly fulfilled at that time than at any time since. Not far from where we are now assembled, stands a magnificent building, bearing the name of the two brothers whose memories will ever be associated with the growth and prosperity of Cleveland. Where that building now stands was a small one-story structure called the 'Ark,' not from any fancied resemblance to Noah's vessel, but, I suppose, because within it was congregated literally all sorts and kinds of animals. Here was the birth-place of science and literature of Cleveland. Here was first brought what might claimed to be a microscope. It was what we would now call a rather inferior instrument; one of Nachet's best, however, as then made. Soon after came one of Spencer's, a perfect marvel then, though it would be considered now little better than a curiosity.

"At that time there were bright and active young men here whose headquarters were the 'Ark,' and they inaugurated the 'Cleveland Academy of Sciences,' afterwards known as the 'Kirkland Academy,' which, it was fondly hoped, would grow and flourish with the growth of Cleveland.

"I trust you will not consider me uncourteous, sir, or as finding fault, if I express my regret that your citizens have allowed this society to exist at present only in name, the valuable collection of books, and the excellent museum, now covered with dust and abandoned to moths. It is a shame for your beautiful city to have allowed this, for no community can afford to disregard the claims of Science."

The Eighth Annual Meeting was then declared opened, and at the request of President Smith prayer was then offered by Rev. Dr. Jabez Hall.

The President called attention to the fact that the by-laws prohibited action by the Executive Committee on a nomination to membership until the entrance fee ($3.00) and the first year's annual dues are paid. He urged the importance of prompt payment of annual dues on the part of members.

On the recommendation of the Executive Committee the following were elected members of the Society: Moses C. White, New Haven, Conn.; Jas. D. Whitley, Petersburg, Ill.; Rev. Haslett McKim, New

Haven, Conn.; Robert Brown, Jr., New Haven, Conn.; Anthony Woodward, New York City; Albert H. Dennett, Lowell, Mass.; E. F. Hodges, Indianapolis, Ind.; Leonidas A. Willson, Cleveland, O.; L. M. Kenyon, Buffalo, N. Y.; W. A. Walker, Utica, N. Y.; A. M. Baker, Buffalo, N. Y.; Wm. S. Tremain, Buffalo, N. Y.; Abram Miller, North Manchester, Ind.; John T. A. Keegan, Indianapolis, Ind.; Harvey H. Chase, Geneva, N. Y., and Charles F. Cox, New York City.

On the recommendation of the Executive Committee, and on motion of Mr. E. H. Griffith, it was decided that papers presented at this meeting, the reading of which will occupy more than twenty minutes, shall be read by abstract, which shall not occupy more than that time.

The following programme of papers for the afternoon was announced and approved: 1. *A New Floscule;* D. S. Kellicott. 2. *Shrinkage of Cement Cells the Cause of Leakage in Glycerine Mounts;* Frank L. James. 3. *The Actinic and Visual Focus in Photomicrography with High Powers;* Jacob D. Cox.

Adjourned, to meet at 3 o'clock P. M.

TUESDAY P. M. Session.

The Society was called to order at 3.25, by President H. L. Smith.

The Executive Committee recommended the election to membership of the following: W. B. Aikins, Toronto, Ont.; Charles Mitchell, Nashville, Tenn.; W. P. Manton, Detroit, Mich.; H. E. Summers, Ithaca, N. Y.; Chas. H. Wrightman, Chicago, Ill.; Joseph Gardner, Bedford, Ind.; and Miss A. R. Taylor, Washington, D. C.

On motion they were elected members of the Society.

By resolution Dr. S. M. Mosgrove was appointed Assistant Secretary for the Cleveland meeting.

Dr. C. H. Stowell moved that immediately after the adjournment of this session a special meeting shall be called to take action regarding the death of Dr. T. S. Up de Graff. The Chair stated that, if no objection was made, he would call such a meeting at the time and for the purpose mentioned.

The Society then took up the reading and discussion of papers.

1. *A New Floscule.*—D. S. Kellicott.

DISCUSSION: Judge Cox asked for further explanation of the reasons for referring this species to *Floscularia* rather than *Stephanoceros.*

The reply was: The cilia are not in "whorls," like those of *S. Eichhornii*, but are long and rigid, like those of *Floscularia*, and tufted somewhat at the extremities of the lobes; in fact, it appears to differ from *F. Coronetta* in having the arms longer and without knobs at the extremities; the gelatinous case, also, is like those of the common floscules, rather than like that of *Eichhornii*. On these accounts, the species had been referred to *Floscularia*; however, should the young prove to have a single eye, I should prefer to place it with *S. Eichhornii.*

Dr. Fell spoke of the importance of investigating the minute forms of "pond-life," and of the work of this kind done by the local microscopical society in Buffalo.

Mr. Mills asked if the lobes were not more flexible than those of *Eichhornii*. It was stated that the lobes are quite flexible and capable of independent motion; they appear to be more flexible than those of the species mentioned, as they are also much more slender.

2. *Shrinkage of Cement Cells the cause of Leakage in Glycerine Mounts.*—Frank L. James.

DISCUSSION: Dr. C. H. Stowell said that the paper covered the subjects of glycerine mounts and white-zinc cement. He favored

glycerine as a medium for histological mounts. Formerly he had had much trouble; now that he had secured proper cement and had learned to properly make the cells with it he had no difficulty. In proof, as he thought, of Dr. James' theory, he gave an instance of a person who introduced an air-bubble in a glycerine cell, because, he said, it was better preserved from leakage. His present method was to build up the cell in parts, giving ample time for drying. When complete it is put on the turn-table, a thin ring run on, filled with glycerine, the object introduced and the cover brought into place, and a thin ring run on; after drying again a thicker ring and final finish is added.

To mount in balsam in white-zinc cell, the ring is covered with colorless marine glue, and then mounted as usual.

W. H. Walmsley advocated glycerine mounts, and gave his methods of making white-zinc cells, which were mainly as previously described. The chief feature was to thoroughly dry the ring.

Dr. Thomas Taylor said he had purchased about forty of Mr. Walmsley's slides ten years ago; they are still good.

Gen. J. D. Cox made some remarks relating his experience in mounting parts of inserts in glycerine and glycerine jelly in cells without pressure; after the lapse of some ten years, a part of them are still good; from time to time some had failed; finally, he had discovered his error, *i. e.*, in using too large covers, so that there was not sufficient depth of cement at the edge of the same.

Discussion: Prof. H. L. Smith remarked that the difficulty experienced by Gen. Cox was the same which, in a still more striking manner, was to be observed with the telescope when employed in celestial photography. The lenses when properly corrected for producing sharp photographic images were entirely useless for eye-observations, and the same was true of lenses used in ordinary photographs. In making photographic pictures by ordinary microscope objectives there were two modes of using them, one by projection of images without an intervening eye-piece; the other with the use of

the eye-piece, or an amplifier, and in the latter case the image sharply focused on the glass would give a sharp photographic picture, at least that seemed to be the general experience.

Dr. Taylor asked if a vernier would not be of service in obtaining exact focus. Judge Cox replied that it would in delicate adjustments. He uses a Darlot focusing-glass and adjusts so as to read print on under surface of a clear piece of glass; he used an old negative-plate cleaned off.

Dr. H. J. Detmers presented a photo-microscope of *Amphileura pellucida*, taken by lamp-light. He said it was made by a very simple arrangement, but they are such as to make the light absolutely central, provided the Abbé condenser is first centered, which is always done. As to focusing, he used a No. 1 eye-piece, fitted in a piece of wood, which takes the place of the plate holder; he also smears the ground glass with a little cedar oil, and then focuses on the ground glass with a one-inch objective.

Prof. T. J. Burrill remarked that he thought that the photographs of *A. pellucida* presented by Dr. Detmers were the first to have been made successfully by lamp-light.

W. H. Walmsley said he wished to raise the question, What is the proper use of the words "micro-photography" and "photo-micrography"? Discussion followed, the point of which was that usage should conform to the definitions of these words in the latest editions of our standard dictionaries.

The discussion of papers finished, the president announced that the Society would now consider what action to take regarding the death of one of our foremost members, Dr. Thad S. Up de Graff, of Elmira, N. Y. He recalled his very efficient service rendered the Society at former meetings, especially at Elmira.

Dr. C. H. Stowell said he had differed with the deceased on many points of science, but he had always found him generous and hearty.

Dr. George E. Fell spoke as follows:

"Dr. Up de Graff had much to do with the present existence of the Society; he came into it at a most critical period in its existence. Some of the circumstances connected with the Columbus meeting would be of interest to the members, as at this time the Society reached its lowest ebb; its enemies were maliciously predicting a speedy death; it was confidently stated by some that the Columbus meeting would be its last. This opposition, I am confident, has had much to do with the success of the Society, as it spurred the active supporters to renewed and determined efforts for its welfare.

"I shall never forget my experience on my trip from Buffalo to attend the meeting at Columbus, and some circumstances connected with the opening of that meeting. Dr. George E. Blackham was one of the Vice-Presidents of the Society, and resided in Dunkirk. I stopped at Dunkirk and ascertained that from a press of business he would be unable to attend the Columbus meeting. Special efforts were made with the view of bridging over the difficulties, but without success. Continuing on my way and arriving at Cleveland, I met Mr. Vorce, who was in the same predicament, *i. e.*, unable to attend from press of business. With him I called on our late esteemed friend and counselor Dr. Wm. B. Rezner, also a Vice-President of the Society. The atmosphere was ominous, I assure you, when he informed us that it was impossible for him to be at Columbus; certain cases in hand were of such a nature that he could not get away. Furthermore, the information that the President, Mr. J. D. Hyatt, from a recent death in his family, could in no event be on hand, made the prospects indeed look depressing. Dr. Rezner, however, could not go, and I traveled on alone, arriving at Columbus the afternoon of the day preceding the meeting.

"From one of the hotel proprietors of Columbus I ascertained where the reverend gentleman in charge as the chairman of the 'Local Committee,' resided. I repaired to his residence and learned from his wife that he was on a convalescent tour 'down in the State of Maine.' I asked about the meeting of the Society. She had heard something about it; nothing definite had been done with reference to it; there were some letters pertaining to it in the house which I could have if I desired. I was indeed making progress, and ascertained where Prof. A. H. Tuttle, the secretary of the society, resided. I found his house closed, and was informed by his neighbors that he was 'away on his vacation.'

"With somewhat depressed spirits, I returned to the hotel, inquired again about Prof. Tuttle, and was referred to a certain book-store near by, where I fortunately found him. Although just recovering from a severe illness, he immediately set about making arrangements for the meeting. This was done 'with a vim,' all taking hold.

"Now and then a member of the Society would make his appearance; when Hamilton L. Smith, Mr. E. H. Griffith, Dr. A. B. Hervey, Mr. Walmsley, and at last Dr. Geo. E. Blackham presented themselves we knew a meeting was assured, that the last meeting of the American Society of Microscopists was not yet held, and that if a Royal Society of Microscopists existed in England, there was as good

reason for the existence and active being of an American Society of Microscopists.

"While we had a good, profitable meeting at Columbus, it was not until Doctors Up de Graff and Gleason, of Elmira, were announced, that the enthusiasm reached its highest pitch, and when the invitation from Dr. Up de Graff to visit Elmira, coupled with the request 'to bring your wives and daughters and leave your pocketbooks behind,' was reached, the future meetings and success of the Society seemed assured. The election of Dr. Blackham as President, Prof. Kellicott as Secretary, with a good board of assistants, has carried us from the dark days of uncertainty to the more satisfactory atmosphere of assured success, which the future, I trust, will only intensify.

"Will any one who attended the Elmira meeting ever forget how thoroughly the promises of Dr. Up de Graff were fulfilled? It is true we needed no pocketbooks after stepping from the cars at that hospitable town. The name of Up de Graff will be inseparably connected with our grand reception, and the great success of the meeting at Elmira, which was the beginning of the real prosperity of the Society."

The Society then adjourned, to meet at 8 o'clock to listen to the annual address of the President.

TUESDAY EVENING.

The Society, with a few visitors, assembled at 8 o'clock in the Probate Court-room for the President's annual address. Gen. J. D. Cox, ex-President of the Society, in introducing the speaker referred pleasantly to the fact that in times past Professor Smith was an Ohioan engaged in teaching in Kenyon College. He was happy to introduce one who, for a generation, has been a recognized leader, in both Europe and America, in an important department of science. The address was a discussion of the "Unconscious Influence of Natural Science Studies."

At the close, with Vice-President Stowell in the chair, a hearty vote of thanks, on motion of Gen. Cox, was given Prof. Smith for his able and timely address.

Adjourned, to meet at 9.30 A. M. in the Probate Court-room.

WEDNESDAY, August 19, A. M. Session.

The Society was called to order in the Probate Court-room, at 10 A. M., President H. L. Smith in the chair.

The minutes of Tuesday's sessions were read and approved.

The following, on the proper recommendation by the Executive Committee, were elected members of the Society: Edward F. Beckwith, Urbana, O.; Herbert R. Spencer, Geneva, N. Y.; Charles Blasdale, Jericho, N. Y.; Jas. H. Logan, Pittsburgh, Pa.; Chas. C. Mellon, Pittsburgh, Pa., and E. Hoxie Sargent, Ithaca, N. Y.

The presentation of papers then followed.

1. *Some Remarks on Fatty Infiltration of the Liver.*—L. M. Eastman.

DISCUSSION: Dr. C. H. Stowell asked: 1. Is there any difference between normal and abnormal fatty infiltration of the liver? and cited cases in which liver containing fat appeared to be normal. 2. Has Dr. Eastman succeeded in staining such tissues with hæmatoxyline? 3. What is the microscopical appearance of the liver tissue in yellow atrophy?

Dr. Eastman replied, that such infiltration becomes abnormal when so much fat infiltrates that the function of the organ is interfered with. He had not used hæmatoxyline in this case, but in its use in other cases, he had used a solution of alum for removing excess of color, instead of acetic acid. Concerning yellow atrophy, he said, experience shows that it assumes a granular condition, and owing to albumen not being restored, the liver contracts.

Dr. Fell asked how to distinguish between fatty degeneration and yellow atrophy. Eastman considers that the former causes the latter.

Dr. Stowell asked if we can not have fatty infiltration alone, *i. e.*, not associated with other diseases, *e.g.*, tuberculosis. Dr. Eastman

said the liver may be largely stored with fat without disease, as sedentary habits or special food may cause large increase of fat in the liver for a while, but a change in the mode of life or food may scatter the fat.

Dr. S. O. Gleason suggested that the disease was caused by paralysis of terminal nerve fibers of the cells, due to mechanical pressure.

2. *On the Determination of the Absolute Length at 62° F. of Eight Rowland Gratings for the Determination of Wave Length.*—Wm. A. Rogers.

On account of the unavoidable absence of the author the paper was read by title.

3. *The Uredineæ of Illinois.*—T. J. Burrill.

DISCUSSION: H. F. Atwood asked about a fungus which he had found on pine needles. Dr. Taylor explained the structure of the cup fungus, which he supposed was the one inquired about. Mr. Atwood said he had not seen it in the stage of an ordinary cup fungus; on opening the needles an orange colored powder appeared.

A. B. Leckenby asked about the favorable conditions for the propagation of these fungi. Prof. Burrill suggested that electrical conditions may influence their growth. He was satisfied that they were true parasites; he thought that rapidly-growing grain, for example, may be attacked more readily than other, because its tissues are less able to resist their attacks.

4. *Butter and Fats—How to distinguish one Fat from another by means of the Microscope.*—Thomas Taylor.

DISCUSSION: Dr. Fell referred to Dr. W. T. Belfield's paper on Lard Adulteration read at the Chicago meeting of the Society, and to the practical value of such tests. He moved that a committee of

three be appointed, as requested by Dr. Taylor, to examine and report to the Society concerning the methods and claims of Dr. Taylor. The motion was carried. The Chair reserved the appointment of the committee.

Dr. Detmers spoke of Dr. Belfield's work in detecting adulteration of lard; he said in a large packing-house in Chicago, which killed daily 8,000 hogs, he could not get one half-ounce of pure lard; he also spoke of families being poisoned by made butter.

Dr. Taylor spoke of market men disguising butterine and selling it for pure butter. He, at request, had examined a number of cases successfully, and restraining measures had been enacted in Washington, so that now specimens had to be correctly labeled.

5. *Pollen-tubes again.*—John Kruttschnitt.

The Chair announced the committee on examination of Dr. Taylor's paper as follows: Dr. H. J. Detmers, Dr. Geo. E. Fell and Mr. C. M. Vorce. [Subsequently, Dr. Lester Curtis and Mr. H. F. Atwood were added to the committee.]

Adjourned to meet at 3 P. M.

WEDESDAY P. M. Session.

The Society was called to order by President H. L. Smith at 3 P. M.

On motion of the Executive Committee, these were elected members of the Society: A. W. Brayton, Indianapolis, Ind.; Albert A. Wright, Oberlin, O.; M. L. Seymour, Normal, Ill.; Marshall D. Ewell, South Evanston, Ill., and John L. Skelton, Chicago, Ill.

The first paper was entitled—

Poisonous Dried Beef.—H. J. Detmers.

DISCUSSION: Dr. Stowell said he thought that Dr. Detmers was perhaps on the eve of an important discovery; that cases are on record in which the mother, having become frenzied, her nursing child sickened and died in consequence; he thought Dr. Detmers was not warranted in concluding that because he found micrococci in this instance the beef creature was frenzied.

Dr. Detmers replied that he did not say posivively that an animal subjected to the tortures of travel in a crowded car and chased over the city streets, or that had been trampled on by other cattle in a car, were subject to frenzy.

Dr. S. O. Gleason said Dr. Detmers had made two points of especial interest, viz., ptomaine and micrococci; ptomaine is developed by a fermenting process; micrococci develop an alkaloid ptomaine, and he therefore thought Dr. Detmers right and that the ptomaine was the cause of the death.

Dr. Fell asked, What is the effect of trichinæ in ordinary cases? he said many must be eaten, as Dr. Detmers had found 5 per cent. of the hogs affected by the worm; that many physicians did not look for serious results when but a small portion of affected meat was eaten.

Dr. Detmers said that he found numerous trichinæ in fat hogs and not in emaciated ones.

Dr. Salmon Hudson said trichinæ do not harm one if well cooked; that he really thought that a majority of people were affected more or less with the parasite.

Dr. Detmers added that trichinæ are very easily destroyed; if the western farmers were all compelled to kill and burn their affected hogs, the pest could be eradicated in a few years,—the hog being a short-lived animal.

2. *Immersion Objectives.*—Ernst Gundlach.

In the absence of the author, the paper was read by Mr. H. H. Turner.

DISCUSSION: Prof. Burrill recalled an experience of his,—an objective, a $\frac{1}{10}$ inch, made before homogeneous objectives were in use, did not come up to expectation in performance; he happened to try it on an object under a *thick* cover, when its performance was excellent.

Judge Cox explained this by referring to an experiment by Dr. J. J. Woodward, in which he built up the cover with additional thin covers until it was thick enough to completely fill the space between the front of the objective and the object, thus making it homogeneous. He said, it appears that Mr. Gundlach proposes to do away with homogeneous immersion fluids at the expense of working distance, when this is a quality we most assuredly want. It was the objection formerly made against wide-angled objectives that they had not sufficient working distance to render them practical; the great charm of the homogeneous immersion objective is its ample working distance and at the same time superior performance.

Prof. Burrill asked, What is the difference of refraction when a thin or a thick layer of water is used as an immersion medium?

The president in reply said that in using water the rays are refracted in the water; on emerging they take a course parallel to that pursued in the cover, so if we can use a homogeneous medium we can use any thickness of cover less than the working distance of the lens.

Prof. A. H. Tuttle had some doubts about the practicability of the proposed plans. He hoped that we may yet have dry lenses sufficiently good. The biologist must have lenses with working distance; the great value of homogeneous immersion objectives is that they enable one to work *within* the object.

The Chair said that the committee appointed this morning to report upon Dr. Taylor's paper had asked to have two others added to the committee; no objection being made, he would appoint two additional members. He named H. F. Atwood and Lester Curtis.

H. F. Atwood said it had been requested that the Society assemble in the park at some convenient time during the meeting in order that a photograph may be taken by Mr. Ryder; he moved that the Society shall comply with this request immediately on adjournment of the Thursday A. M. session. Carried.

Dr. Fell moved that Dr. Wm. J. Lewis, Judge J. D. Cox, and Mr. H. F. Atwood be made a special committee on finance; the object being to institute some plan by which a permanent fund shall be accumulated. The resolution was adopted.

3. *Observations on Infusoria, with Descriptions of New Species.*—D. S. Kellicott.

The paper was read by title.

Dr. C. H. Stowell then took the chair and the President read the following two papers:

4. *On a Simple Instrument for Testing Homogeneous Immersion Fluids.*—H. L. Smith.

5. *On some Formulæ for High Refracting Media for Mounting Microscopical Objects.*—H. L. Smith.

Dr. Detmers remarked that Prof. Smith had mounted in this medium for him a micrometer; the lines show in a superior manner.

6. *The Cultivation of Bacteria with Special Reference to Cholera.*—Lester Curtis.

Dr. Detmers moved a vote of thanks to Dr. Curtis for his able presentation of this important matter. Carried unanimously.

Adjourned.

THURSDAY, August 20, A. M. Session.

The Society proceeded with business at 9.30 A. M., President Hamilton L. Smith in the chair.

The following were elected members of the Society: Sereno N. Ayres, Jamestown, N. Y., and Walter M. Miller, Portsmouth, O.

Dr. H. J. Detmers moved that a committee be appointed by the Chair to report on the advisability of the publication of a quarterly microscopical journal by this Society. After brief discussion, the motion was put, and the chair thought the motion lost, and so declared it. Mr. H. F. Atwood said he thought the question was not fully understood, and asked to have the motion again voted on. The Chair said: "If no objection is made, I will ask the Society again to vote by the uplifted hand." The vote was so taken and pronounced lost.

The following brief descriptions of new and improved apparatus were then presented:

1. *The Griffith Turn-table, No. 5.*

2. *The Griffith Turn-table, No. 6.*

3. *The Griffith Mechanical Finger.*

4. *The Griffith Stage Diaphragm.*—E. H. Griffith.

The President said he considered Mr. Griffith's turn-tables valuable improvements.

Mr. R. N. Reynolds asked about the manner of centering certain slides. Mr. Griffith explained.

The Chair said the time had arrived for election of a Nominating Committee, said committee to consist of seven members; as usual, they would be elected by ballot, after free nominations, the seven having the greatest number of votes being elected. Nine persons were nominated.

C. H. Stowell and H. F. Atwood were appointed tellers, after which the ballot was taken.

While the votes were being counted by the tellers, the hearing of papers was again resumed.

5. *Method of Mailing Histological Sections.*

6. *Method of Preparing a Fresh Balsam Mount for Transportation.*

7. *Method of Marking the Position of an Object on a Slide.*—R. N. Reynolds.

Dr. Taylor remarked that he had found trouble in making the adhesive strip of paper stick to the slide in such cases as that mentioned in transportation and the like: he now added a little glycerine to the gum and found it work far better.

8. *Notes on the Epithelium of the Mouth of Necturus.*

9. *Notes on the Blood Corpuscles of Necturus.*—Simon H. Gage.

Discussion: Dr. Stowell dissented from Prof. Gage's conclusions; he did not think it followed that if one cell had or appeared to have a network, that all cells must have such; it was necessary to know what reagents were used and what objective; he held that reagents produce appearances which are often mistaken for structure; he disbelieves in the cellular network theory, also in the third corpuscle.

Prof. Gage said he had enjoyed the speech in reference to intercellular network, etc. He referred to the difficulties in the way of the observations made, such as the disproportionate number of red to white corpuscles, etc.; had not seen the latter after the blood was drawn; probably overlooked on this account; he defended the third corpuscle element, holding that it was proven; was not satisfied about the motion of the white corpuscle of *Necturus*. He said he was not crazy on the subject of objectives; he considered a

morphological insight better than any fifty horse-power objective. In reply to queries by Dr. Dayton, Dr. Curtis and Dr. Fell, he said he had not found two kinds of white corpuscles, but had seen granules in white corpuscles; had not mounted them; had studied the living elements; had seen what might fairly be interpreted to be an intercellular network. He said the ablest histologists in Europe at present believe in the theory of the network, and in such matters they are very cautious and painstaking; they are content to work and get their reputation after they are dead, while we work ten days and want our ability recognized right off.

The report of the Tellers on vote for Nominating Committee was then read; the committee elected: Dr. Robert Dayton, Chairman, Edward Bausch, Dr. H. J. Detmers, Dr. Frank L. James, Dr. Wm. J. Lewis, Dr. S. M. Mosgrove, Dr. J. O. Stillson.

10. *First Development of Muscle in Embryos of Chicken and of Man.*

11. *Studies of the Development of Cartilage in the Embryos of Chicken and of Man.*—M. L. Holbrook.

These papers were read by title.

13. *Two Cases of Tumor of Mammary Gland in Lower Animals.*—A. H. Tuttle.

Discussion: Prof. Gage said it was held not many years since that animals did not suffer from disease unless contaminated by man; he mentioned two cases of fish caught with hook which had tumors; had found cyst of the oviduct in *Necturus.*

Dr. James said that when he went to Mississippi County, Ark., in 1870, they were very much troubled with wolves, which made such frequent inroads upon their flocks that sheep-raising became almost impossible. After a few months these attacks ceased, and the reason of the cessation was made apparent by finding the wolves lying dead all through the woods—killed by the "black tongue." The domestic cattle had had the disease, and from them it spread to the deer.

The wolves ate the dead bodies and themselves died. So great was the mortality among the wild animals that several years elapsed before deer or wolves became at all plentiful in a region that had formerly swarmed with them.

Dr. Detmers asked if it was not just as likely that the cattle caught the infection from the deer as *vice versa?*

Dr. James replied, "Yes, for the deer might have been dying off for some months before it was noticed by the residents, as the country with the exception of a belt a mile or two wide along the river (Mississippi) was an unbroken wilderness for hundreds of miles north and south, and for fifty or sixty miles west to the St. Francis river."

Dr. Gleason had found tumors of considerable size on woodchucks.

These were elected members of the Society: Miss Mary M. De Veny, New York City; M. A. Veeder, Lyons, N. Y.

Adjourned, to meet at 2 P. M. in Le Grand Rink, for Working Session, and for Annual Soirée in the evening at the same place.

Thursday Afternoon and Evening.

In the afternoon the Society, with many visitors, assembled in Le Grand Rink to witness expert methods of work, explanation of special apparatus, etc.; for a full account of this Working Session see page 203 of the first part of this volume.

The Annual Soirée occurred in the evening at the same place as the Working Session; the rink proved to be an admirable building for the purpose; although hundreds of people visited the room there was no crowding or inconvenience. The Soirée at Cleveland adds one more successful exhibition to the brilliant series of popular entertainments at our annual meetings.

FRIDAY, August 21, A. M. Session.

The Society called to order at the usual time, Vice-President C. H. Stowell in the chair.

The following were elected members of the Society: F. P. Anderson, Belle Isle, Mich.; G. C. Stockley, Cleveland, O.; Geo. W. Leighton, Wheeling, W. Va., and W. H. Johnston, Notre Dame, Ind.

Moved by the Secretary that the Chair appoint a committee of two to revise the Constitution and By-Laws of the Society. The motion was carried and Judge J. D. Cox and Dr. Wm. J. Lewis were appointed such committee.

Dr. F. S. Newcomer moved a vote of thanks by the Society to the reporters and newspapers of the city for their kindness in printing notices and abstracts of the proceedings of this meeting. Carried unanimously.

Dr. L. M. Eastman moved that the thanks of this Association be tendered to Mr. C. M. Vorce and his assistants for their unceasing and well-directed labor in preparing for the conveniences of this meeting. Carried unanimously.

Gen. Cox said: "Mr. Chairman, the custom of giving our thanks to our retiring officers is a good one, but there is some danger that it may become too merely formal. Our President, whose necessary absence this morning we regret, has not only discharged his official duties with ability, courtesy and dignity, but I know I speak the feeling of the whole Society when I say that it has been a constant delight to us to have him in our midst, and that we have constantly followed him with our warm affection, as well as our heartfelt respect. We all earnestly hope he may many years be spared to lead us in everything which pertains to microscopy, and to raise the character of our deliberations by the wisdom and sweetness of his influence. In this spirit I move that the most hearty thanks of this Society are tendered to Prof. Hamilton L. Smith for the manner in which he has discharged the duties of the Presidency during the year past.

Dr. Fell seconded the resolution, which was carried by a unanimous standing vote.

The nominating committee, by its chairman, Dr. Robert Dayton, reported the following: For President, Prof. T. J. Burrill, Champaign, Ill.; Vice-Presidents, Dr. F. S. Newcomer, Indianapolis, Ind., and Dr. Wm. J. Lewis, Hartford, Conn.; Members of the Executive Committee, Dr. F. L. James, St. Louis, Mo., Jno. Kruttschnitt, New Orleans, La., and E. H. Griffith, Fairport, N. Y. On motion the Secretary was directed to cast the ballot of the Society for the nominees; they were declared elected. [D. S. Kellicott, Secretary, Buffalo, N. Y., and Dr. Geo. E. Fell, Treasurer, Buffalo, N. Y., hold over by virtue of election at Rochester until the annual meeting of 1887.]

Dr. Lucien Howe moved the appointment of a committee to devise and report a plan by which any member may have sections of any subject made for him. The motion prevailed, and Dr. Howe and Dr. Geo. Duffield were made such committee.

It was moved by Dr. James that a committee be appointed to devise some means of arranging and preserving the photographs of members of the Society which the forethought of Mr. Griffith had secured, and that the thanks of the Society be tendered to Mr. Griffith. It was adopted.

Dr. James and Dr. Dayton were appointed and requested to report before final adjournment.

The matter of Working Session for the next annual meeting was by resolution referred to the Executive Committee.

Then followed the presentation of papers.

1. *An Imperfection of the Eye and Test Objects for the Microscope.*—Lucien Howe.

Dr. F. S. Newcomer said he considered the paper a valuable one; it was true that no two eyes were alike, hence the importance of an

examination into the nature and peculiarities of the eyes before examining test objects. Persons habitually using spectacles should not remove them when using the microscope.

2. *Methods of Preparing Chick Embryos for Microscopic Examination.*—W. P. Manton.

Prof. Gage thought any one may succeed by following the directions indicated in the paper.

Dr. S. Hudson preferred an incubator to a hen for the development of the eggs.

3. *Rapid Section-Cutting.*—James E. Whitney. Read by title.

4. *Some Diatom Hoops, and the Question of their Mode of Growth.*—Jacob D. Cox.

[Mr. C. M. Vorce's remarks after the reading of this paper are printed in full at page 139.]

Gen. Cox said Mr. Vorce's observations corroborated his remarks on *Isthmia* printed in the *American Microscopical Journal* some years ago.

5. *Urinary Deposits and their Clinical Relations.*—Salmon Hudson.

6. *Tables of Numerical Apertures.*—H. J. Detmers. Read by title.

Dr. Fell called attention to the fact that the picture of Mr. Tolles, in the Proceedings of the Rochester Meeting, was quite satisfactory to Mr. Tolles' family, although evidently not satisfactory to the editor of *Science.*

A communication was then read and referred to the Executive Committee, inviting the Society to meet next year at Chautauqua, N. Y. It was as follows:

In behalf of the Chautauqua Assembly I invite the American Society of Microscopists to make Chautauqua, N. Y., their place of meeting next year.

The Assembly will make hotel rates $2.00 per day, and cottage board $1.00 per day.

It may be urged that there are always excursion rates to Chautauqua. There are ample rooms for all the meetings; freedom from noise and dust; and sympathetic and appreciative audiences.

If the last week in July should be determined upon as the time for the meeting, during the teachers' annual gathering, it is likely many will become members.

Good facilities exist for the use of projection microscopes.

W. C. J. HALL,
Trustee of Chautauqua Association.

CLEVELAND, O., August 20, 1885.

Adjourned to meet at 2 P. M.

FRIDAY P. M. Session.

Society called to order by Dr. Stowell at 2 P. M.

Judge Cox, for the Committee on Revision of Rules, reported progress. The committee would endeavor to complete its revision in time for insertion in the printed Minutes.

The Secretary read the report of the committee appointed at Rochester to consider the feasibility of collecting typical slides illustrating special methods and objects. The following is the amended report, which was adopted:

The committee appointed at the Rochester meeting, with instructions to report upon a plan for collecting, storing and circulating typical slides of microscopical preparations, report the following: It is considered by the committee both desirable and feasible for the Society to acquire, hold and circulate, for the advantage of the members, typical slides of mounted objects and illustrations of special methods, especially slides illustrating the memoirs and communications to the Society's Proceedings. Authors of papers and inventors of methods of preparation will undoubtedly take pleasure in depositing with the Society slides illustrating their conclusions, and it is believed that such slides will greatly assist students, and that members will gladly take advantage of the opportunities of such collection. It will certainly put within reach of those who doubt others' conclusions the means for examination better than mere drawings and descriptions.

Rules for storing and circulating the objects are suggested as follows: The full size Pillsbury Microscope Slide Cabinet appears to be convenient for this purpose. One cabinet would be sufficient for the present, and additional cabinets may be purchased as they may be needed. For circulating the slides by mail, Bradley's Mailing Cases are handy for transporting a few slides at once; two dozen should be secured. For sending larger numbers to one address, the boxes used by the American Postal Microscopical Club are more convenient and safer; a half dozen of these, it seems, will be sufficient.

Each package mailed should have a printed label pasted on the wrapper, in order to secure the return of packages not properly delivered; it may read as follows: "Should this package, for any reason, fail to reach the person to whom it is addressed, the *Postmaster* will confer a favor by notifying———, who will forward postage for its return to him." Tags should also be used on the mailing boxes, and the name and address of the custodian of the collection printed on them.

It is recommended that a list of the objects at present owned by the Society shall be printed in the Proceedings of this meeting, and that annually hereafter lists of the slides added during the year shall be likewise printed, together with remarks by the Curator on the condition of the collection, and with lists of slides lost, ruined or withdrawn from circulation.

The list, or catalogue, shall be printed with the names alphabetically arranged and the slides numbered consecutively. A slide may be catalogued under more than one name, if necessary, but shall have but one number.

The boxes for storing the slides should be marked according to the designation in the printed catalogue (as above), and the name of the slide be written opposite its number on the box label.

Each slide should bear the Society's label, color French gray, as follows:

AM. SOC. MIC.
Box..........
No...........

The letters designating the box and the number should be stamped on with types, which may be obtained from any printer; this in order not to violate postal rules.

The slides may be sent to any member on application, or to any person, not a member, engaged in investigation, upon the personal endorsement of a member, who shall, under such circumstances, become personally responsible for the return of the slide or its value. Slides should be sent in the order of application, and should be returned as soon as two weeks after being received.

A record, kept in a suitable book, of applications, the date of mailing and return of slides, with record of postage paid and returned by members, should be annually presented to the Auditors of the Society for inspection and approval.

It is suggested that authors be asked to deposit in this collection slides illustrating their descriptions; also that this request extend backward in time to those whose papers have already appeared in the Proceedings.

D. S. KELLICOTT,
LOUISA REED STOWELL,
FRANCIS M. HAMLIN,
Committee.

Dr. Fell reported for the Committee on the Standard Micrometer, and moved that Dr. R. H. Ward, of Troy, be added to the committee. The report was accepted, and Dr. Ward added to the committee.

Dr. Fell reported as Treasurer and Custodian. Gen. Cox moved the adoption of the report. Carried.

Dr. Fell moved that the Treasurer and Custodian of the Society shall be required to furnish a bond for $1,000, which shall be approved by the Executive Committee; said bond to be in the custody of the Secretary. The resolution was adopted.

Dr. James moved that illustrations of papers presented should be furnished by the authors, when exceeding a limit to be fixed by the Executive Committee.

Gen. Cox and Dr. Detmers advocated leaving the matter in the hands of the Publication Committee as at present.

Gen. Cox moved a substitute that the Committee on Publication be authorized to limit the amount expended for illustations at their discretion as to the needs and importance of the papers. The substitute was accepted and adopted.

Papers were then presented:

1. *Improved Method of Constructing Slide-Cabinets.*—Henry E. Summers.

2. *A Combined Focusing and Safety Stage for Micrometry with High Powers.*—C. M. Vorce.

3. *A New Heliostat.*—S. W. Stratton and T. J. Burrill.

The paper was read by the latter.

4. *An Improved Life-Slide.*—Jas. H. Logan.

Read by the Secretary.

5. *Remarks on a New Device for Enabling Two Observers to View an Object Simultaneously.*—Jas. H. Logan.

Read by title.

6. *Some New Features in Connection with Electric Illumination as applied to the Microscope.*—Wm. J. Lewis.

Read by title.

The Committee appointed to report a plan for the custody of the photographs of members rendered the following report :

We would recommend that the Treasurer be authorized to receive the photographs from Mr. Griffith and take charge of them and those which shall be received in the future. We will also recommend that he be authorized to procure a suitable album, substantially bound and large enough to contain the pictures of all present and prospective members, to the number, at least, of five hundred pictures. This album shall be in charge of the Custodian.

FRANK L. JAMES,
ROBERT DAYTON.

Dr. Fell reported the condition of the Spencer-Tolles memorial fund. The report is as follows :

SPENCER AND TOLLES FUND.

To the Officers and Members of the American Society of Microscopists :

In accordance with the resolution *unanimously* adopted at the Rochester meeting of the Society, establishing a Spencer and Tolles Memorial Fund, the following report is presented : The first cash subscription to this fund was made by the Royal Microscopical Society, December 17, 1884. Since that time the subscriptions have come in so slowly that this report will present but a meager list of subscribers, and in view of the unanimous adoption of the resolution establishing the fund, not nearly so large a list as should have been expected. Prof. Wm. A. Rogers, with his characteristic action in furthering any of the projects of the Society, has offered to subscribe $25.00 and guarantee $15.00 additional, contingent, however, upon a concerted action of the Society towards the increase of the

fund. He suggests that the income of the fund be awarded in prizes for specific original research. The subscriptions to the fund are given below.

Royal Microscopical Society	$25.20
J. D. Cox	5.00
D. S. Kellicott	5.00
George E. Fell	5.00
John Kruttschnitt	5.00
F. S. Newcomer	5.00
Chas. Shepard	5.00
E. H. Griffith	5.00
Total	$60.20

Respectfully submitted,

GEORGE E. FELL,
Treasurer and Custodian.

Gen. Cox moved that the Secretary acknowledge the receipt of the contribution to the fund by the Royal Microscopical Society, and express the appreciation of this Society for the courtesy. Carried.

The Chair said that the time had come to terminate the business of this annual meeting, a meeting which he trusted all would remember with pleasure and profit. He thanked the members for courtesy shown him as presiding officer for the day in the absence of President Smith, and requested Gen. Cox and Dr. Dayton to conduct President-elect Burrill to the chair, which he would then resign.

Prof. Burrill said, on taking the chair :

Members of the Society—I have sometimes looked up from below at a man performing in the air on a rope or horizontal bar, climbing about in a graceful and apparently careless manner, and thought, from my safe standpoint, that it was an easy thing to do. I stand here now under somewhat similar circumstances. I have, from my seat among you, watched other presiding officers who have preceded me as President of this Society, and they performed the duties of their office so well, and with apparently so little effort, that I have thought it an easy thing to do. I now find that the elevation is greater than it looked to be from below. I will endeavor, however, to perform the duties of the office to which you have so kindly elected me, to the best of my ability, and shall endeavor to do so to your satisfaction. I thank you for the election and for your cordial reception.

Dr. Stowell then moved the Society adjourn *sine die.*

D. S. KELLICOTT,
Secretary.

S. M. MOSGROVE,
Assistant Secretary.

MEMBERS.

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J. M. ADAMS.....Watertown, N. Y.
W. H. B. AIKINS, M. D.....Toronto, Ont.
IRA W. ALLEN, LL.D.....1832 Michigan Ave., Chicago, Ill.
CHAS. E. ALLING, F. R. M. S.....Rochester, N. Y.
F. P. ANDERSON, A. B., M. D.....Grosse Isle, Mich.
W. H. ATKINSON, M. D., D. D. S.....41 E. Ninth St., New York City.
E. S. ATWOOD.....East Orange, N. J.
H. F. ATWOOD, F. R. M. S.....Rochester, N. Y.
SERENO N. AYRES.....609 Pine St., Jamestown, N. Y.
JOHN A. BAGLEY, C. E.....45 East 28th St., New York City.
E. STILLSON BAILEY, M. D.....3034 Michigan Ave, Chicago, Ill.
ABRAM D. BALEN, F. R. M. S.....Plainfield, N. J.
ALEXANDER BARCLAY.....St. Paul, Minn.
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CHAS. H. BASSETT.....504 Washington St., Boston, Mass.
EDWARD BAUSCH.....179 and 181 N. St. Paul St., Rochester, N. Y.
GEO. R. BAUSCH.....20 Arcade, Rochester, N. Y.
EDWIN F. BECKWITH, M. D.....Urbana, O.
W. T. BELFIELD, M. D.....45 Clark St., Chicago, Ill.
M. LOUISE BERNEIKE, M. D.....208 Warren St., Brooklyn, N. Y.
H. G. BEYER, M. D.....U. S. National Museum, Washington, D. C.
I. A. BIDAMAN, M. D.....Buffalo, N. Y.
W. H. BIRCHMORE, M. D.....Box 13, Carbondale, Kan.
GEO. E. BLACKHAM, M. D., F. R. M. S.....Dunkirk, N. Y.
CHARLES BLASDALE, M. D.....Jericho, N. Y.
A. M. BLEILE, M. D.....277 S. Fourth St., Columbus, Ohio.
W. G. BLISH.....Niles, Mich.
JOHN BOLTON.....68 Huntington St., Cleveland, Ohio.
MARY A. BOOTH.....Longmeadow, Mass.
S. T. BOYD.....Parson's College, Fairfield, Iowa.
A. W. BRAYTON, M. D.....Indianapolis, Ind.
W. H. BREARLY.....“Evening News,” Detroit, Mich.
C. M. BRIGGS, M. D.....Fairport, N. Y.
ALBERT P. BROWN, Ph. D.....Cor. 5th and Federal Sts., Camden, N. J.

ROBERT BROWN........................Observatory Place, New Haven, Conn.
REV. J. T. BROWNELL, A. M...Tangerine, Fla.
W. H. BULLOCH, F. R. M. S..........99 and 101 W. Monroe St., Chicago, Ill.
T. J. BURRILL, Ph. D., F. R. M. S...........................Champaign, Ill.
EDWIN K. BUTTLES, A. M....................................Geneva, N. Y.
HARRY T. BUTTOLPH, C. E....................................Buffalo, N. Y.
WILLIAM L. CARPENTER, U. S. A............................Dunkirk, N. Y.
GEO. H. CHAFFEE, M. D...................................Le Raysville, Pa.
H. B. CHAMBERLIN..Denver, Col.
HARVEY H. CHASE, M. D....................................Geneva, N. Y.
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S. V. CLEVENGER, M. D.............Cook County Insane Asylum, Chicago, Ill.
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